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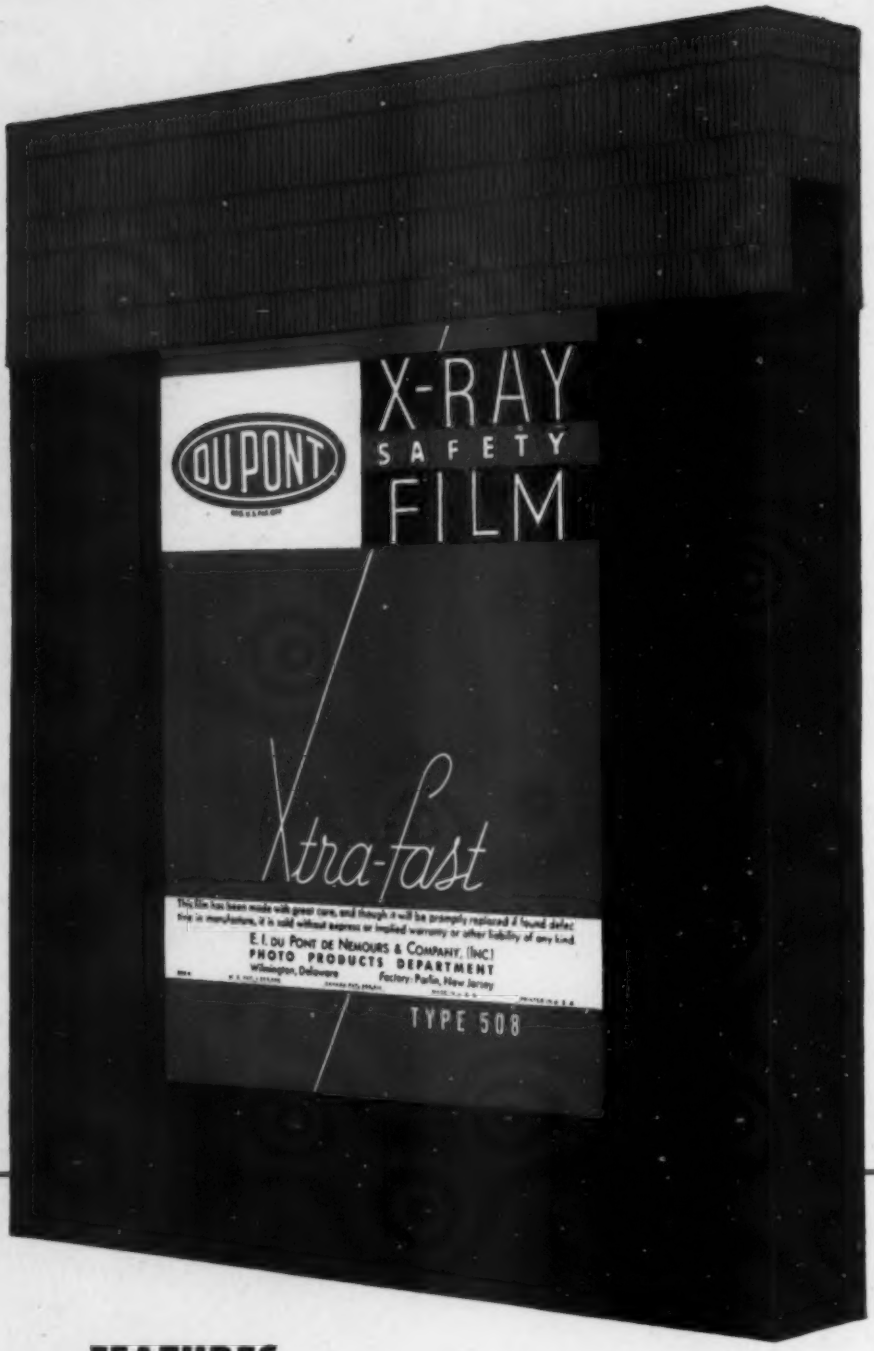

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 57 APRIL, 1947 No. 4

ELECTROKYMOGRAPH FOR RECORDING HEART MOTION, IMPROVED TYPE*

By GEORGE C. HENNY, M.S., M.D.,
BERT R. BOONE, *Senior Surgeon, U. S. Public Health Service,*
and
W. EDWARD CHAMBERLAIN, M.D.

SINCE reporting our first work on the "electrokymograph for recording heart motion utilizing the roentgenoscope,"[1] we have considerably improved and simplified parts of the apparatus. Unusual interest has been shown in this development. It seems worth while, therefore, to report our progress.

APPARATUS

The electrokymograph employs a roentgen-ray pick-up device which, when properly placed over the roentgenoscopic cardiac silhouette, translates the motion of this silhouette border into a varying electrical current. The current is recorded with the aid of a standard electrocardiographic machine. Our recent work has been done with a machine of the string galvanometer type (Cambridge "Simplitrol"). However our earlier work showed that the amplifier type electrocardiograph can be used directly with our apparatus and that satisfactory records can be made by this method. (We have not yet worked out a simple method of simultaneously recording the carotid pulse and the electrokymogram, when employing the D'Arsonval galvanometer in the amplifier type electrocardiograph.)

The roentgenoscope is operated at ordinary kilovolt and milliampere values. The electrocardiographic machine also is operated at its usual sensitivity, and the paper at the usual speed, 25 mm. per second. The familiar timing lines are present, and these, as in the electrocardiogram, are indispensable in making precise time-interval measurements.

The pick-up (Fig. 1) consists of a lead diaphragm (*4*, Fig. 1) with an aperture 5 by 20 mm., behind which is placed a piece of fluorescent screen close to an RCA 931-A multiplier phototube. The light-emitting surface of the fluorescent screen (Patterson, Q29-774C)† is close to, and faces, the photosensitive surface of the 931-A phototube (*1*, Fig. 1). The fluorescent light, produced by the roentgen rays which pass through the patient and the lead dia-

† This is an experimental screen which emits fluorescent light of a color within the more sensitive region of the photoelectric surface of the 931-A tube. Patterson Type B screen has also been used.

* From the Departments of Radiology and Medical Physics, Temple University Hospital and Medical School, Philadelphia, Pennsylvania.

phragm, illuminates this surface. The phototube is thus activated. The tube and fluorescent screen are mounted in a light-tight metal housing which has an 8 by 25 mm. window in the back. This window allows the roentgen rays which pass through

up device and the moving border of the cardiac silhouette.

Maintenance of a correct relationship between pick-up device and heart border is facilitated by an improved mounting (Fig. 2). The housing of the phototube is at-

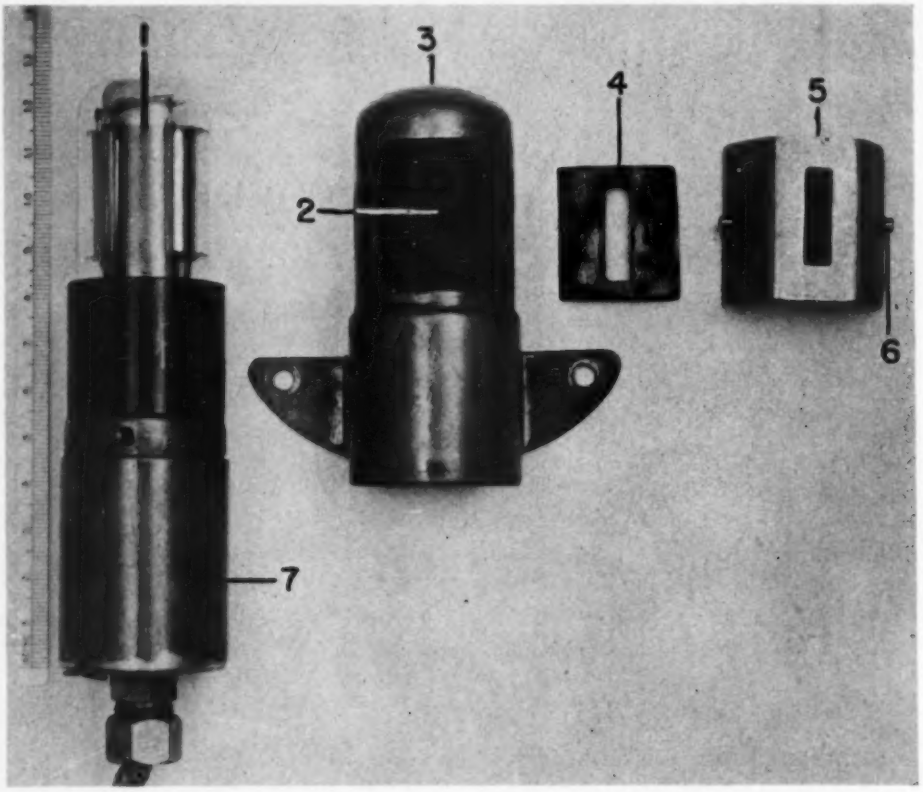

Fig. 1. Pick-up of the electrokymograph showing the component parts. *1*, RCA 931-A multiplier phototube, looking at the photosensitive surface. *2*, window covered with black paper to exclude room light. A small piece of fluorescent screen is directly under this window with light-emitting surface facing the photosensitive surface of the 931-A tube. *3*, metal housing placed over 931-A tube and supporting the lead diaphragm. There is a window directly opposite *2*, allowing roentgen rays to pass through. *4*, lead diaphragm with aperture 5 by 20 mm. placed directly over *2*. *5*, hood holding lead diaphragm in place is screwed onto the housing. *6*, one of two beads which cast shadows on the roentgenoscope screen to aid in alignment of the diaphragm on the cardiac silhouette. *7*, metal housing around resistor network. The shielded-cable attachment is seen at the bottom.

the patient, through the lead diaphragm, and through the tube, to fall on the roentgenoscope screen. The outline of the diaphragm may be observed and the alignment is simplified. We have placed two small projecting beads of metal on the sides of the housing (*6*, Fig. 1) to help in maintaining a correct relationship between the pick-

tached to a circular disc (diameter 5 inches) of laminated plastic (5/16 inch thick, canvas impregnated with phenol-base plastic, trade name Micarta). This disc has the center portion cut out in order to obstruct the roentgen-ray beam as little as possible. Visibility of the portion of the cardiac shadow under investigation is thus in-

creased. The disc is grooved and turns with little friction on three bearings in a frame (*4*, Fig. 2) made of the same phenol-base plastic material. It is easily rotated in this frame by turning a knob at the corner of the roentgenoscope screen. The central axes of the diaphragm, of the disc, and of the roentgen-ray beam, are made coincident. When the disc and housing are rotated, the diaphragm rotates around its center. Thus, when turning the diaphragm to place its axis at right angles to the heart border, the center does not shift. Accurate alignment is facilitated and the time required to obtain the electrokymogram is greatly reduced. The whole phototube housing and support are mounted on the patient side of the regular roentgenoscope screen by clamps. This part of the apparatus is light enough so that it does not appreciably disturb the balance of the roentgenoscope screen. The housing and its support may be swung up from the screen so as to be out of the way for routine roentgenoscopy.

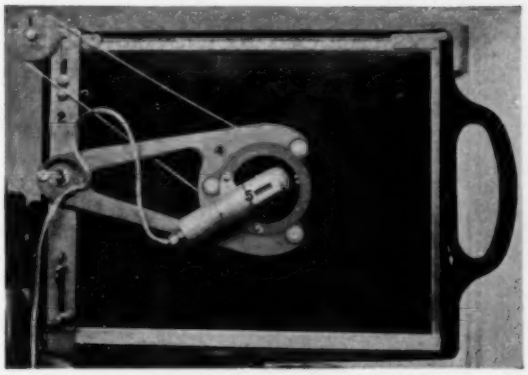

FIG. 2. Rear view, showing electrokymograph mounted on back (patient's side) of roentgenoscope screen. *1*, pulley which rotates the pick-up via the belt. This is rotated by a knurled knob projecting from the operator's side of the screen. *2*, adjustable bracket holding the device on the roentgenoscope screen. *3*, pivot on which the pick-up may be moved upward and out of the way for routine roentgenoscopy. *4*, bracket holding the pick-up head. *5*, pick-up which is centered to the roentgenoscope beam and which may be rotated about an axis coinciding with the central ray of the roentgen-ray beam.

On the phototube socket are mounted ten resistors to form a voltage divider (Fig. 1 and 3). The resistor between dynode No. 9 and the anode has been reduced to 50,000 ohms, thus reducing the voltage applied to the anode. This change and the low voltage (1,000 volts) we apply to the voltage divider were recommended by the tube manufacturer, and result in greatly improved stability with little sacrifice in sensitivity. The leads from the pick-up to the power supply and to the recording galvanometer are made of high grade shielded single conductor microphone wire. This wire is employed because of its flexibility, thus allowing free motion of the roentgenoscope screen and free rotation of the pick-up. It should be handled carefully and without kinking.

The power supply to operate the 931-A tube should give 1,000 volts. The total current drain is only about 1.6 milliamperes and consequently it can be made relatively small and can conveniently be mounted on a chassis 6 by 14 inches. The output is well regulated by a voltage stabilizer in the primary circuit. The schematic wiring diagram of the whole apparatus is shown in Figure 3. By using a voltage doubling circuit, a standard radio power transformer may be employed. A 120 cycle ripple is impressed on the direct current output and this can be more easily filtered than the 60 cycle ripple of our previous apparatus. A small neon lamp (L_1, Fig. 3) is incorporated in the circuit as a voltage indicator. When this lamp glows it indicates that sufficient voltage is being supplied to the multiplier phototube. There is also a small pilot light connected to the power transformer that lights when it is energized. In case of poor connection to the power line or of failure of any of the components in the power pack, the operator will be warned immediately and the location of the trouble will be facilitated.

Since the pulsating roentgen-ray beam would produce an undesirable ripple on the recorded curve, we have employed a filter to remove this ripple. We have found it

expedient when building this filter to employ small non-inductive (carbon) potentiometers for the resistors so that the filter can be adjusted or "tuned" to a balance for the individual components used. Commercial fixed resistors and condensers vary too much from their stated values to assure a balanced circuit. After final balancing, the filter is placed in its box, no further adjustments being required. This filter is connected between the output circuit of the 931-A multiplier phototube and the string galvanometer (Fig. 3). It must be designed for the particular type of rectification employed in the user's roentgenoscope. For a roentgenoscope using a full-wave rectification system (120 pulses per second) a simple single filter as indicated (*AB*, Fig. 3) is adequate to remove essentially all of the ripple and to give a smooth curve without introducing appreciable distortion. With a half-wave rectification roentgenoscope (60 impulses per second) the filtering becomes more difficult. It was found that two of the filters in series, as indicated in the lower portion of Figure 3 (A^1B^1) were required to produce clean ripple-free records. This arrangement was further tested to be sure that the heart motion "signal" current was not adversely distorted.

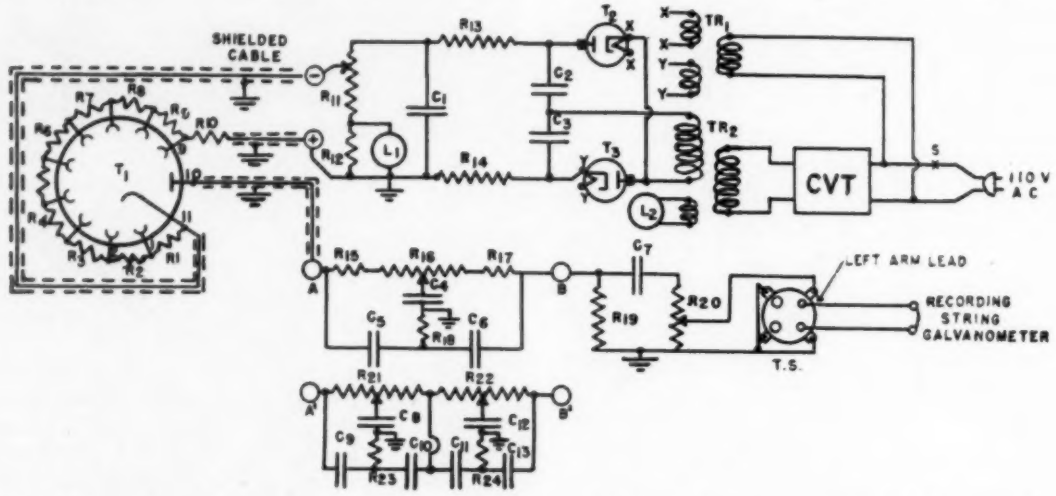

FIG. 3. Schematic wiring diagram of the electrokymograph. R_1 to R_9 = 0.1 megohm, half watt resistors. R_{10} = 50,000 ohms, half watt. R_{11} = 2 watt resistor, approximately 1.7 megohms, adjusted to give output of 1,000 volts to tube network. R_{12} = 150,000 ohms, 2 watt. R_{13} = 0.2 megohm. R_{14} = 0.1 megohm, 2 watt. R_{15}, R_{17} = 10,000 ohms, half watt. R_{16} = 20,000 ohm potentiometer (carbon). R_{18} = 17,500 ohms, quarter watt. R_{19} = 1 megohm, half watt. R_{20} = 10,000 ohm potentiometer (carbon), linear taper. R_{21}, R_{22} = 100,000 ohm potentiometer (carbon), linear taper. R_{23}, R_{24} = 7,000 ohm, quarter watt. C_1 = 2 mfd. 1,500 volt. C_2, C_3 = 1 mfd. 1,000 volt. C_4 = 0.18 mfd. paper. C_5, C_6 = 0.05 mfd. paper. C_7 = 2 mfd. paper. C_8, C_{12} = 0.06 mfd. 400 volt paper. C_9, C_{10}, C_{11}, C_{13} = 0.1 mfd. 400 volt paper. T_1 = RCA 931-A multiplier phototube. T_2, T_3 = 2 × 2 (879) rectifiers. TR_1 = SNC 4P222 dual filament 2.5 volt transformer. TR_2 = SNC 8P186 power transformer 325–0–325 volts. *CVT* = Sola constant voltage transformer, 301003, 15 watt. L_1 = G. E. three-quarter watt, 125 volt neon lamp. I_2 = 6 volt pilot lamp. *T.S.* = binding post terminals into which the tips of the electrocardiograph leads are inserted. *S* = power line switch. The filter between *A* and *B* eliminates 120 cycle ripple (full-wave rectified roentgenoscope). The other filter, shown between A_1 and B_1, is used in place of the first when the roentgenoscope is of the self-rectified or half-wave type. Ground connections are indicated by the usual symbol.

A condenser input to the galvanometer, as indicated by the 2 microfarad condenser (C_7, Fig. 3), and the 1 megohm resistor, is used to simplify centering of the string and thus to facilitate the operation of the apparatus. The average roentgen-ray intensity producing fluorescent light in the pick-up device results in a considerable direct current component from the 931-A tube.

This current would cause the galvanometer string shadow to move off of the paper if it were not centered with the compensator or with the mechanical shifter. By using the condenser coupling, the direct current component is blocked out while the varying current from the heart border motion passes through to the string. It is necessary to have a high resistance-capacitance time constant in this circuit, otherwise a heart border motion having a sustained flat plateau would be recorded as a steeply sloping line.

The 100,000 ohm potentiometer (R_{20}, Fig. 3) is used as a "volume control" to regulate the excursion of the string shadow for the particular recording to be made. It should be turned down before starting (in order to protect the string). Then, after the roentgen-ray beam is turned on and the pick-up device is properly aligned over that portion of the cardiac border to be studied, the potentiometer is turned up until the deflections of the galvanometer string are satisfactory. The patient is asked to stop breathing wherever he is in the respiratory cycle, the camera is started, and the electrokymographic record is made. After the camera is stopped, the potentiometer may be rapidly rotated to the zero position and the roentgenoscope then turned off.

As the output of the 931-A multiplier phototube was found to be adequate in practically all cases to operate the string of the galvanometer, the previously used amplifier and its power supply could be eliminated, and a great simplification of the apparatus effected.

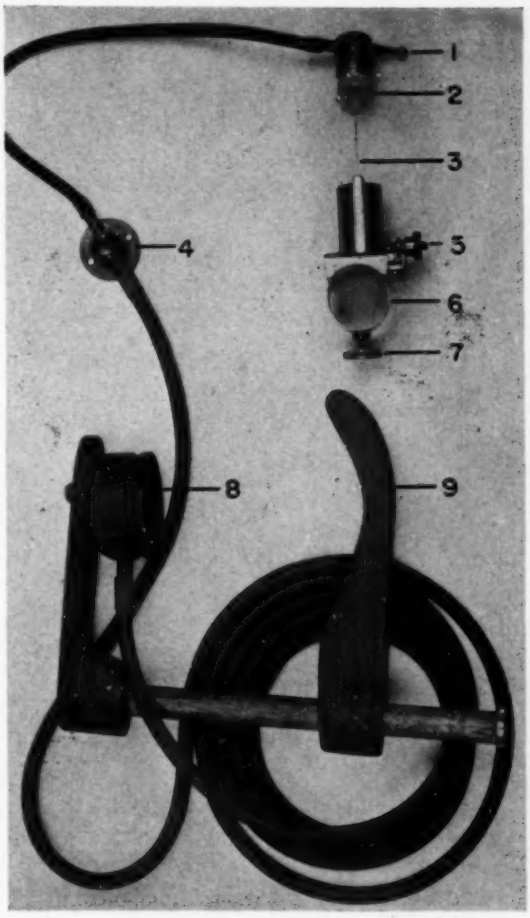

Fig. 4. Equipment used to record the patient's carotid pulse. *1*, handle to rotate tambour and pointer, giving adjustment of shadow amplitude. *2*, rubber diaphragm on which is cemented l-shaped, aluminum, pointer holder. *3*, fine wire pointer. *4*, air vent in pulse conduction system. *5*, platform with adjusting screw affording lateral alignment of pointer shadow. *6*, ring slipping over lens tube of string galvanometer. *7*, set screw. *8*, cup for placement over patient's carotid artery. *9*, opposing part of clamp, curved to fit patient's neck.

THE PULSE RECORDER

We have found that for constructing simultaneous ordinates on the time axes of two or more electrokymograms (on the same patient) the pulse of the carotid artery is the simplest and best phenomenon to employ. To record this pulse, a bakelite cup 3 cm. in diameter (*8*, Fig. 4), is clamped over the patient's carotid artery so that it is held comfortably in place. The cup should be made shallow so as to include as little dead air as possible. The clamp may be made with wooden brackets which are held in place to fit the patient's neck. In our latest model the connecting metal cross piece is made of telescoping members which are keyed so that rotation of the wood arm (*9*) is prevented. The clamp is thus adjustable to fit the patient's neck and, after adjustment, is held by a set screw. A rubber tube from the back or the edge of the cup

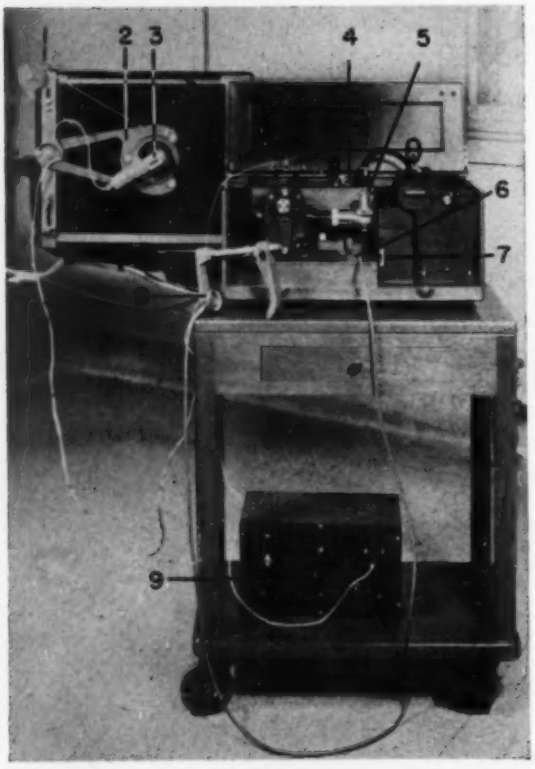

Fig. 5. The complete electrokymographic apparatus showing the pick-up device mounted on the roentgenoscope screen, the power pack, the electrocardiographic machine, the carotid pulse cup and the tambour attachment. *1*, handle on roentgenoscopist's side of the screen by which he may rotate the diaphragm. *2*, bracket holding the pick-up. *3*, pick-up device with lead diaphragm facing the patient. *4*, amplitude control and filter. *5*, carotid tambour attached to lens tube. *6*, air vent in carotid pulse tube. *7*, camera motor switch. *8*, carotid cup and clamp. *9*, power pack for operation of phototube.

conducts the pressure variations to a tambour which is mounted on the string galvanometer lens tube. In the rubber tube, mounted on the electrocardiographic machine close to the camera switch, is placed a small vent (*4*, Fig. 4, and *6*, Fig. 5) allowing equalization of air pressure during adjustment of the cup. When the carotid pulse is tested or recorded, the vent is easily closed by placing a finger on the hole.

The recording tambour (*2*, Fig. 4) consists of a thin rubber diaphragm, 12 mm. in diameter, fastened to a shallow cup in a brass cylinder, 14 mm. in diameter and 25 mm. long. On the rubber diaphragm the base of a small aluminum pointer is mounted with Blue Bond rubber cement.* The pointer, with one end bent at right angles to the base, projects away from, and in the central axis of, the rubber diaphragm. On the end of this portion of the aluminum pointer is cemented a short length of No. 36 B & S gauge copper wire (*3*, Fig. 4). The latter projects into the light beam and thus casts a narrow shadow on the recording paper. The brass cylinder, supporting the rubber diaphragm and the pointer, is mounted in a vertical brass tube so that it may be rotated while the shadow of the end of the pointer is being observed on the scale in front of the recording paper. The rotation adjustment causes the motion of the pointer to vary from a plane which is at right angles to the light beam to a plane that is in the direction of the light beam. The amplitude of motion of the shadow of the pointer therefore varies from its maximum excursion to zero excursion. This adjustment by rotation acts as an amplitude control of the carotid pulse tracing without introducing distortion. It is thus possible to use the same cup on patients with very weak or with strong carotid pulses. In order to easily project the carotid pulse shadow onto that part of the recording paper desired, the capsule and its support are mounted on a small horizontal brass platform. The platform may be moved perpendicularly to the direction of the light beam by turning a knurled adjusting screw (*5*, Fig. 4). This adjustment moves the pointer across the light beam and its shadow across the recording paper. The whole tambour mechanism is clamped in place on the lens tube of the string galvanometer (*5*, Fig. 5).

APPARATUS AS A ROENTGENOSCOPE ATTACHMENT

The electrokymographic apparatus, considered as an attachment to the standard

* So-Lo Works, Loveland, Ohio.

roentgenoscope, consists (Fig. 5) of the phototube pick-up device (*3*) which is clamped onto the roentgenoscope screen, three shielded connecting wires, the power supply (6 by 14 by 10 inches high) (*9*), a small filter box and amplitude control (*4*), and a standard string galvanometer electrocardiographic machine. In addition, there is a cup and clamp (*8*) for obtaining the carotid pulse, a connecting rubber tubing with a vent in it (*6*) which is closed with the finger when the recording is to be made, and the tambour attachment (*5*).

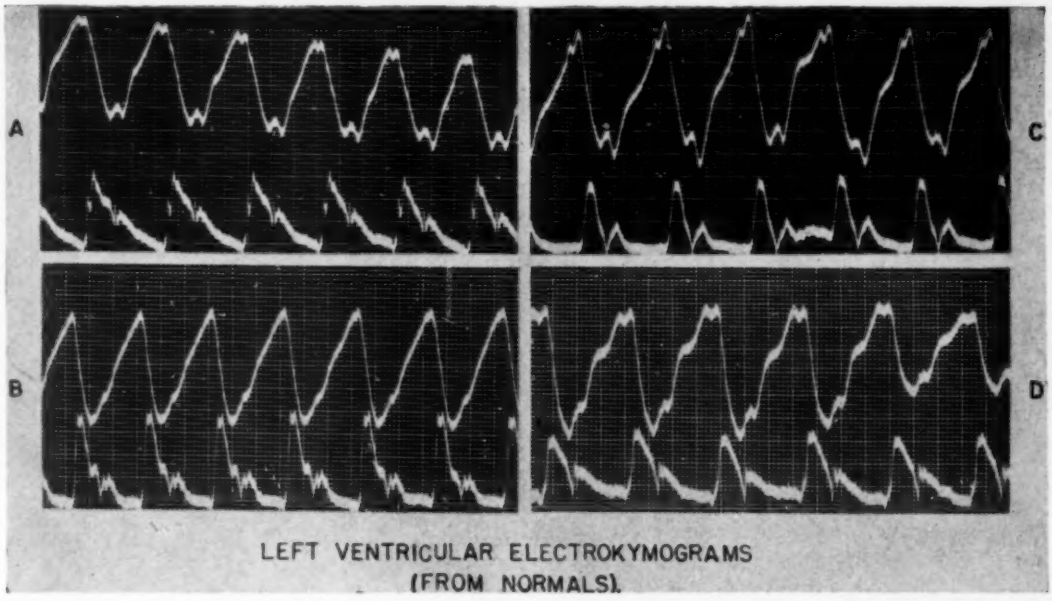

Fig. 6. Typical electrokymograms of left ventricular border motion, with accompanying carotid pulse tracings, on four normal individuals. In each case the electrokymogram is shown above the carotid pulse. Inward motion of heart border is recorded as a downward stroke, outward motion as an upward stroke.

Making of the Electrokymogram

The making of a record after the phototube pick-up has been placed on the roentgenoscope screen is quite simple. The patient is placed against the roentgenoscope panel and the carotid cup is clamped in place. The pulse shadow is tested. The roentgenoscope is then turned on (we usually operate at 85 kv. peak, and 2.5 to 3 ma.) and the diaphragm of the pick-up device is positioned over the cardiac border to be examined. The diaphragm is rotated until its long axis is at right angles to the motion of the cardiac border. The roentgenoscope beam is coned down to just cover the pick-up diaphragm. The amplitude control is turned up until a satisfactory string shadow excursion is obtained (approximately 1.5 cm.) and the finger is placed on the vent of the carotid pulse tube. The latter operations should be done by a technician, thus leaving the roentgenoscopist free to concentrate on the patient. When the amplitudes and the alignment of the electrokymographic shadow and of the carotid pulse shadow are satisfactory the patient is asked to "stop breathing." The camera motor is then started and about ten cardiac cycles are recorded. The amplitude control of the electrokymograph is turned down to protect the string, the patient is told to breathe, and the roentgenoscope is turned off. With the roentgenoscopist well dark adapted and well coordinated with the technician, recordings of six to eight points on the ventral projection of the cardiac silhouette can be made in a very few minutes, without discomfort to the patient.

SAMPLE ELECTROKYMOGRAMS

With the apparatus described here, records of heart border motion have excellent detail and fidelity (Fig. 6). These records are characterized by freedom from ripple and by photographic clarity. The possibility of precise time measurements is evident.

SUMMARY

1. An electrokymograph utilizing the roentgenoscope is described in detail. The apparatus is designed for recording motion of the heart border and is considerably improved and simplified over that of our first described apparatus.[1]

2. The apparatus for recording the patient's pulse is also described.

3. Sample electrokymograms are shown.

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1. Henny, G. C., and Boone, B. R. Electrokymograph for recording heart motion utilizing the roentgenoscope. Am. J. Roentgenol. & Rad. Therapy, 1945, *54*, 217–229.

Vol. 57, No. 4

ROENTGEN MANIFESTATIONS IN THE SKULL OF METASTATIC CAROTID BODY TUMOR (PARAGANGLIOMA), OF MENINGIOMA AND OF MUCOCELE*

A REPORT OF THREE UNUSUAL CASES

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RECENTLY, we have had an opportunity to study 3 unusual cases, all of which had unilateral exophthalmos and osteolytic lesions of the skull. Although the clinical manifestations were similar, the diagnoses, the histories and the roentgen appearances were quite different.

CASE 1. The patient was a white male who was first seen at the age of twenty-four in another institution complaining of a progressively enlarging swelling over the left eye of six months' duration (Fig. 1, *a* and *b*). This had been incised previously and pure blood was obtained. The mass was reported to exhibit non-expansile pulsation, causing a displacement of the eye downward and outward. *There had been a non-pulsatile mass present in the left side of the neck for many years, behind which the carotid was palpable.* A roentgenographic study on February 22, 1939, revealed an osteolytic lesion in the left frontal bone with destruction of the orbital roof and extension into the frontal sinus (Fig. 2). On April 18, 1939, the left common carotid artery and its superior thyroid branch were ligated in the belief that the patient had an arteriovenous aneurysm at the carotid sinus. The supraorbital mass continued to increase in size postoperatively although the pulsation vanished.

The patient was first seen in the surgical outpatient department of the University Hospital on July 7, 1939 (Fig. 3, *a–c*). A roentgen examination on July 11, 1939, showed an increased destruction of the frontal bone, left orbit and frontal sinus. There was evidence of bone proliferation (Fig. 3, *d*). A roentgen diagnosis of angiosarcoma was suggested.

The mass was irradiated through four fields crossfiring over the lesion, each receiving 1,050 roentgens with the following factors: 200 kv., 14 ma., 0.5 mm. Cu and 1 mm. Al added filtration, 50 cm. skin target distance, 12 cm. cone diameter, the treatment being delivered in two weeks. The lesion showed only a slight response.

On August 8, 1939, removal of the tumor was attempted, but because of hemorrhage only a biopsy was done. The mass was solid, contained large blood vessels, and the pathological report was angiosarcoma. On September 16, 1939, the wound was reopened and approximately two-thirds of the tumor was removed. The dura was exposed since the bone behind the mass was eroded. On February 27, 1940, a further partial excision of the tumor of the left frontal bone was done, the extent of the operation being restricted by hemorrhage (Fig. 4, *a*).

The patient began to complain of pain in the back and right ankle in September, 1940. In January, 1941, treatment was instituted to two lateral and one left anterior skull fields because of an increase in the size of the tumor. The dose was 2,000 r per field, measured in air, with the same factors as previously employed, the treatment being administered in five weeks. Again there was practically no response of the tumor to irradiation.

In June, 1941, the mass in the left side of the neck began to enlarge. A tractotomy and cordotomy were done on July 3, 1941, for intractable pain in both legs. On July 12, 1941, the patient developed a pathological fracture of the right femur (Fig. 4, *b*). A chest roentgenogram showed metastases to the lung, and in an examination of the abdomen for suspected ileus, collapse of the fourth lumbar vertebra was found which had resulted from metastases. The patient pursued a retrogressive course and died on November 6, 1941.

The postmortem examination revealed metastases to the lungs, liver, left parietal bone, the fourth cervical, ninth thoracic and fourth

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Fig. 1, *a* and *b*. Case 1. Metastatic carotid body tumor of the skull. Photograph made January 4, 1939.

lumbar vertebrae, pelvis, right femur, multiple ribs and the sternum. The tumor of the left orbital region had invaded the right orbit and the ethmoidal and sphenoidal sinuses. There was a mass in the left side of the neck just below the angle of the jaw which was presumed to be metastatic. The right common iliac vein was invaded.

The tumor was believed to be an angiosarcoma. The histopathological picture was not as convincing as tissue culture which showed growth of solid tubes, which later formed vascular channels with branching as in normal vessels. A recent review of the slides by Dr. Robert C. Horn revised the diagnosis to metastatic caro-

Fig. 2. Case 1. Metastatic carotid body tumor of the skull. Roentgenographic examination February 22, 1939, revealed large osteolytic lesion in the left frontal region invading the left orbit and frontal sinus.

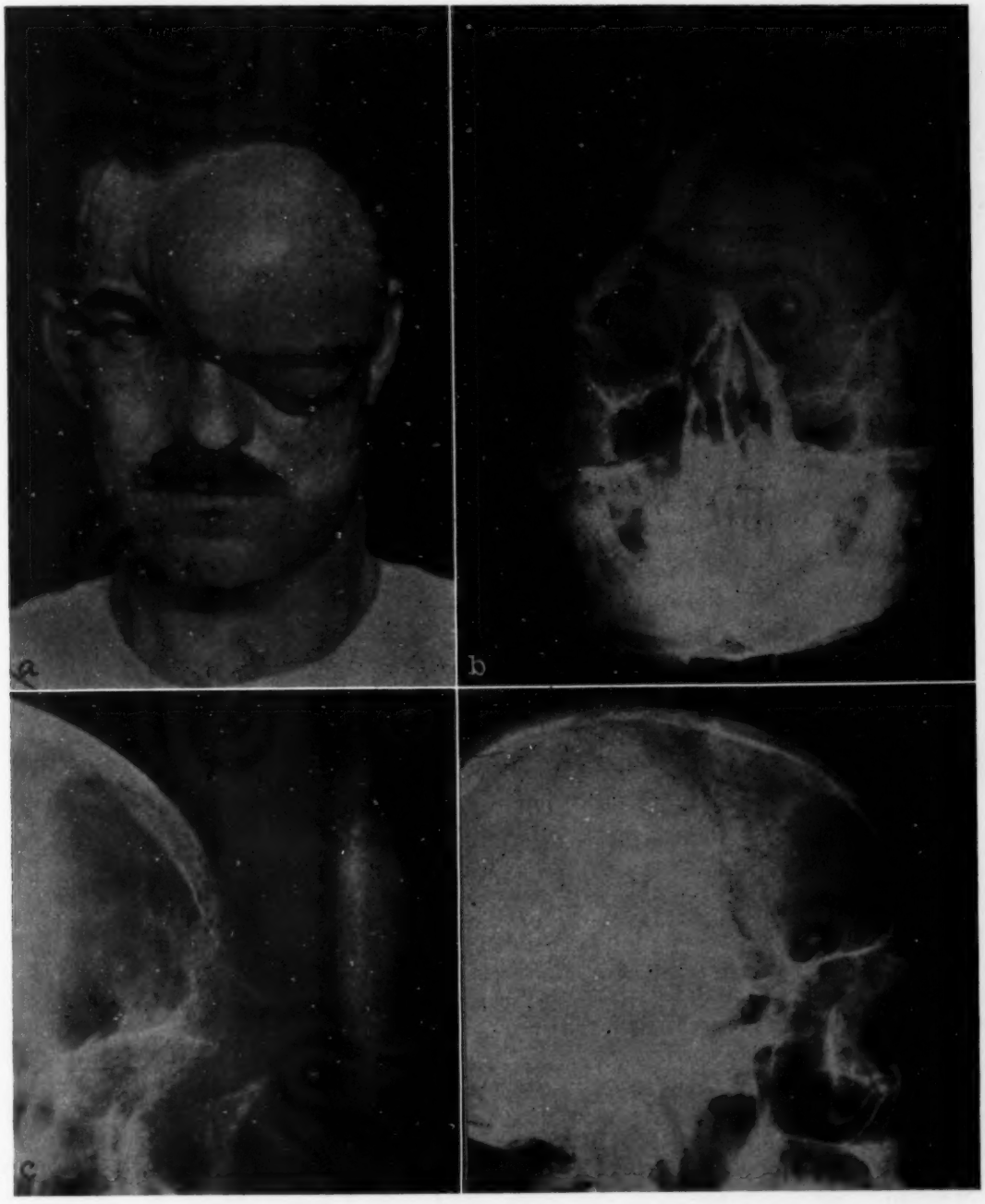


FIG. 3. Case 1. *a* and *b*, metastatic carotid body tumor of the skull. Photograph and roentgen examination made five months later (July 11, 1939) than previous examination (Fig. 2). Increased bone destruction of the left frontal bone, frontal sinus and orbit are shown. *c*, in the lateral view there is evidence of a few fine strands of perpendicular striation. *d*, examination February 15, 1940, shows the extent of the bone destruction in the lateral view.

tid body tumor, this opinion being concurred in by Dr. William E. Ehrich.

Pathological report by Dr. Robert C. Horn: "The same fundamental structure is observed in the primary cervical tumor and in all of the metastatic lesions from which sections were taken. It is somewhat obscured in the surgical specimens by extensive hemorrhage. The tumor

is extremely vascular, the great majority of the vessels being of capillary size and not infrequently impervious. The tumor has an organoid pattern, the cells being grouped in small alveolar clusters about the capillaries. In most of the metastatic lesions the tumor cells are fairly uniform, but occasional giant forms are seen. Bizarre, monster cells are numerous in the primary lesion and constitute a conspicuous feature. Blood vessel invasion is widespread (Fig. 5).

Fig. 4. Case I. *a*, photograph made June 20, 1940. *b*, roentgen examination of the right femur on July 12, 1941, showed metastases throughout the shaft with a healing pathological fracture just below the lesser trochanter.

"The pattern of the tumor closely resembles that characteristic of the paraganglioma, or so-called carotid body tumor, although cellular pleomorphism is unusually marked in this case. This degree of anaplasia has been observed, however, in similar tumors arising in the adrenal gland. Diagnosis: Malignant paraganglioma of carotid body with multiple metastases.'

Pathological report by Dr. William E. Ehrich: "After continued study of the tumor I have come to the conclusion that it is a carotid body tumor rather than an angioma. The tumor is very vascular, which is a usual feature of these tumors, and probably accounts for the outgrowth of blood vessels in tissue culture. The cells which form the nests do not resemble branched, syncytium-like endothelial cells with elongated heavily stained nuclei and a rather homogeneous cytoplasm as found in angiomata, but rather are definitely epithelial. In places they are heavily vacuolated and their nuclei are round and reveal a delicate network of chromatin. Two other characteristics which favor a diagnosis of carotid body tumor instead of angiosarcoma are the presence of considerable Sudan positive fat and the absence of fibrils in the Mallory connective tissue stain. Moreover, the blood vessels contained in the tumor are lined by endothelial cells which are distinct from the tumor cells."

Case II. The patient was a white female,

aged fifty-seven, who was admitted to a mental institution twenty-seven months previously because of a paranoid state. At that time there was exophthalmos of the right eye, and the roentgenograms were said to show a destruction of the roof of the right orbit on the nasal side. Within six months a cystic mass was noted in the right temporal region. Roentgenograms at that time were reported as showing no area of bone destruction which previously was evident. The orbital ridge on the affected side appeared thickened.

The patient lost the vision of her right eye, and the lids became edematous. The tumor grew and extended from the mid-frontal to the right upper parietal region. Subsequent roentgen examinations showed bone destruction which increased in extent.

The patient was transferred to the University Hospital for consideration of surgery (Fig. 7, *a*). The roentgen examination at that time revealed a large soft tissue mass arising in the region of the right frontal bone. There was erosion of the lateral wall of the orbit, the adjacent frontal bone, the greater wing of the sphenoid bone, and, to a lesser extent, the lesser wing of the sphenoid bone. Perpendicular striations of bone were visible in the tangential and Hirtz view (Fig. 6, *a*, *b* and *c*).

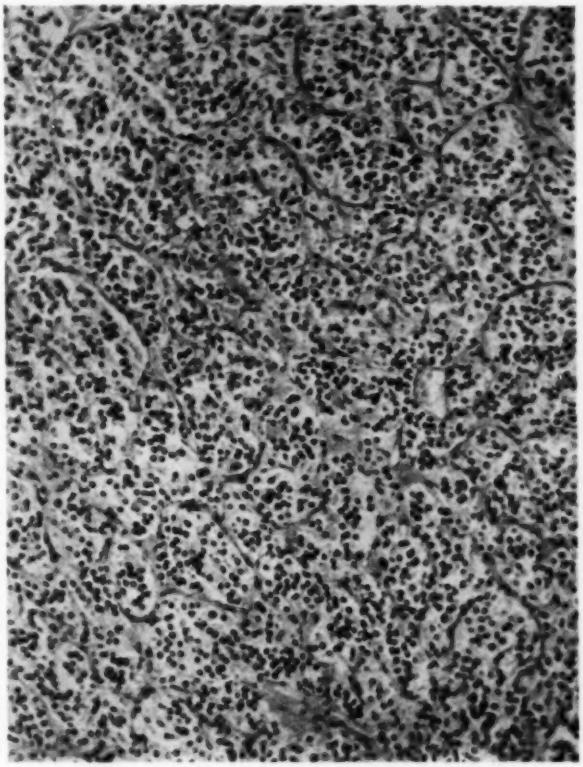


Fig. 5. Case 1. Metastasis in the frontal bone from malignant paraganglioma of carotid body. The high degree of vascularity and organoid pattern of the tumor are apparent. The tumor cells are arranged in small clusters separated from each other by delicate capillaries.

The two roentgen diagnoses that received most consideration were osteogenic sarcoma and angiosarcoma.

On physical examination the head was greatly deformed and asymmetrical, with a huge mass in the frontal, parietal and maxillary regions on the right side (Fig. 7, *a*). The mass was bluish and cystic, and pushed the eye downward and inward.

The patient did not appear fit for surgery, and ten days after admission she went into

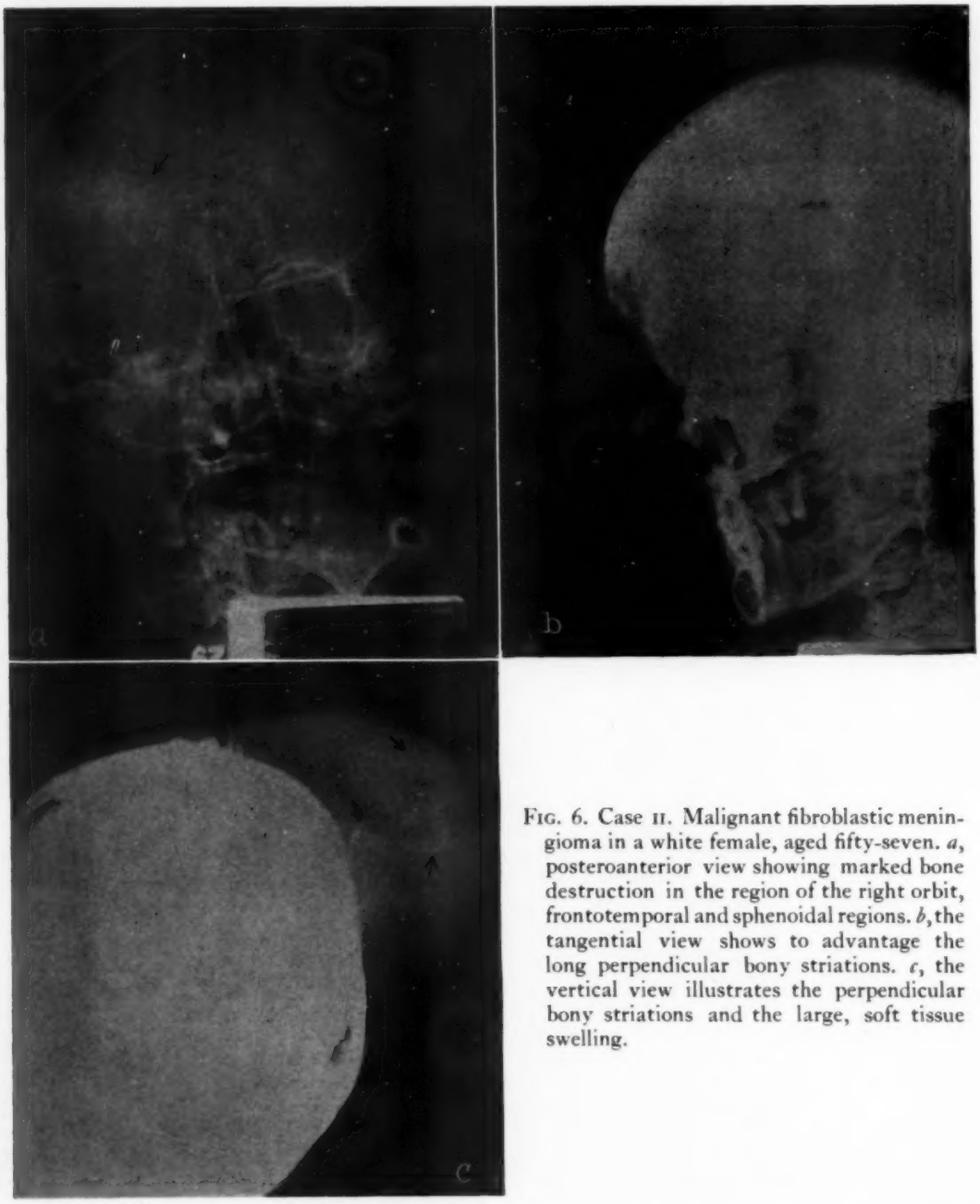
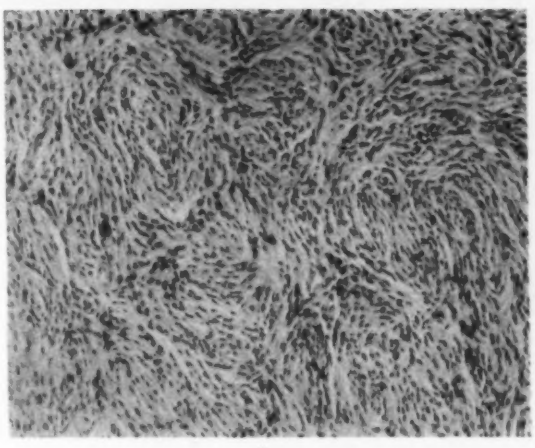


FIG. 6. Case II. Malignant fibroblastic meningioma in a white female, aged fifty-seven. *a*, posteroanterior view showing marked bone destruction in the region of the right orbit, frontotemporal and sphenoidal regions. *b*, the tangential view shows to advantage the long perpendicular bony striations. *c*, the vertical view illustrates the perpendicular bony striations and the large, soft tissue swelling.

auricular fibrillation, developed evidence of a cerebrovascular accident, and died.

Pathological report: Gross description by Dr. William Weiss: "The brain weighed 1,140 gm. The lesion on the right side was found to consist of soft, white, lobulated tissue. It was adherent to the frontal bone and when dissected away, it was fund to perforate the frontal bone. The right orbit was destroyed over an area about 4 by 6 cm. and the bone edges were irregular and thinned. The external mass contained some areas of new bone formation and the surface of the adjacent skull showed spicules of bone perpendicular to the skull surface. When the brain was removed the entire right anterior cranial fossa, orbit, and sphenoid ridge were found to be replaced by a soft nodular tumor tissue which was pale and homogeneous. The



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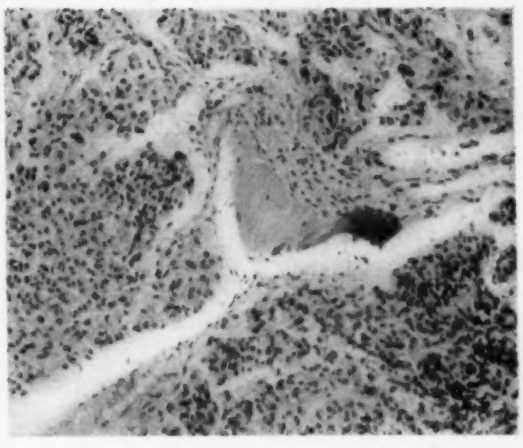

c

FIG. 7. Case II. *a*, meningioma of the right frontal bone. *b*, the pathological pattern is rather typical of that seen in a meningioma. *c*, the pleomorphic areas with numerous cells containing mitotic figures suggest that sarcomatous changes have taken place, such as seen in the sarcomatous meningioma described by Cushing and Eisenhardt. The spicule of bone is thought to be a remnant of the eroded frontal bone.

a

brain surface showed no particular lesion, except for the part which was next to the tumor. Here the basal aspect of the right frontal and anterior temporal lobes were much softened and friable."

Microscopic examination by Dr. Henry A. Shenkin: "In general the sections revealed a tissue predominantly composed of elongated spindle cells running in various directions. Islands of rounded to polyhedral, pleomorphic cells with abundant cytoplasm were scattered throughout. In these islands of cells numerous mitotic figures were seen. Large amounts of fibroblastic, particularly reticulin, tissue had been laid down.

"Sections from other areas revealed typical fibroblastic meningioma, in others, pleomorphic areas with some tendency to whorl formation (Fig. 7, *b* and *c*). Diagnosis: Malignant fibro-

FIG. 8. Case III. Mucocele involving the left frontal, ethmoidal and maxillary sinuses, orbit and frontal bone. The well defined and dense periphery of the bone erosion in the frontal bone is often characteristic of mucocele.

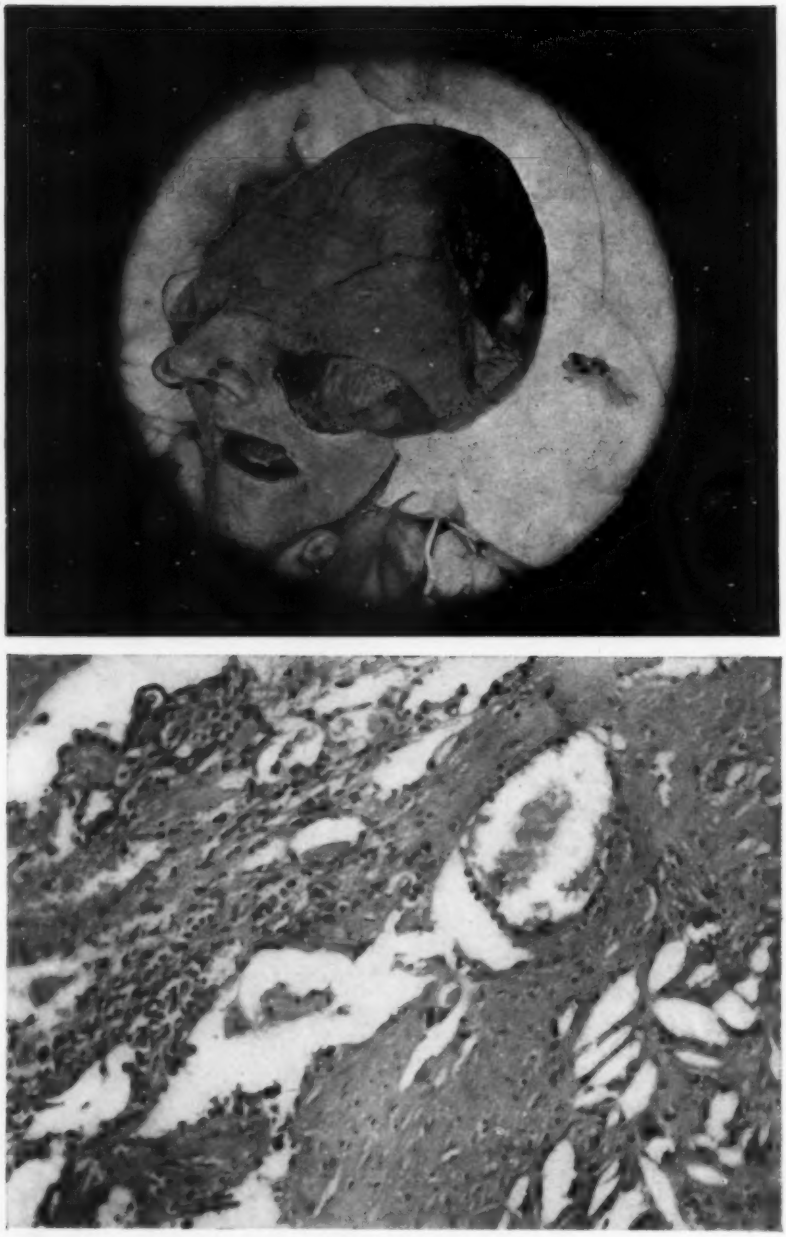

FIG. 9. Case III. *a*, mucocele of long duration in a white female, aged seventy-four. *b*, mucocele of the frontal sinus. In the upper part of the photomicrograph remants of mucus-secreting epithelium are present. Below there are "cholesterol clefts" and occasional foreign body giant cells.

blastic meningioma (sarcomatous meningioma, Type VI of Cushing and Eisenhardt)."

CASE III. The patient was a white female, aged seventy-four, who fell down a flight of stairs fifteen years ago. About three to six months later a swelling appeared over the left eye. She was seen by a neurosurgeon who advised excision in the belief that it was a sphenoid ridge meningioma. This was refused and the mass slowly increased in size until about six months ago it began to enlarge rapidly, pushing the eye outward and downward. The mass was not painful or tender, and it changed

in character from hard to soft. About twenty-four hours prior to admission it ruptured spontaneously near the inner canthus and drained foul smelling brown material.

The patient was admitted in partial physical shock and in auricular fibrillation. When first seen there was soft red skin covering a partially collapsed cystic mass protruding from the left orbit and measuring about 6 inches in diameter (Fig. 9, *a*). The upper portion of the lesion appeared to be gangrenous. The roentgenographic examination revealed an area of bone destruction on the left side involving the frontal bone, orbit, frontal, ethmoidal and maxillary sinuses (Fig. 8). The left orbit, left frontal sinus and left maxillary sinus and ethmoid cells were unrecognizable. Due to the well defined dense periphery of the bone erosion in the frontal bone, the lack of perpendicular striation and the relation of the lesion to the paranasal sinuses, a diagnosis of mucocele was suggested.

On November 24, 1944, the neurosurgeon cut across the gangrenous area with the electrosurgical knife and entered the sac. The gangrene extended down to the base of the wound. A line of cleavage between what must have been tumor capsule and the overlying skin was found and the bulk of the gangrenous material was removed. This left the patient with a white shiny cavity about 10 by 12 cm. across the surface and at least 14 cm. deep. The eyeball and optic nerve were cut and removed by the ophthalmologist in attendance. What remained of the orbital contents was removed more posteriorly and the optic nerve cut off close to the foramen. Nothing resembling dura was encountered and the whole surface of the inside of the cavity appeared to have been covered with pericranium. There was no escape of cerebrospinal fluid at any time.

The patient died twenty-nine days postoperatively of what appeared to be a cerebrovascular accident. Autopsy permission was refused.

Pathological report: Gross examination by Dr. Henry A. Shenkin: "The specimen consists of numerous large pieces of flattened brownish and, in some parts, gangrenous appearing tissue weighing a total of 80 gm. Most of the pieces have one surface that is smooth and shiny with many vessels running through them, the opposite surface being quite fibrous in appearance. One large piece contains what appears to be remnants of the orbit, the cornea and iris being opaque and having a greenish tinge."

Microscopic examination by Dr. William E. Ehrich: "The wall of the mucocele where preserved is lined with a greatly thickened mucosa showing a papillary structure, the individual papillae being covered with disorderly, low, obviously glandular epithelial cells. The stroma shows fibrosis and hyalinosis and considerable round cellular infiltration in places. The underlying bone is partially resorbed. The few bone spicules left are covered with a recently laid-down osteoid tissue.

"Parts of the wall of the mucocele are necrotic and infiltrated with fibrin and polymorphonuclear leukocytes. The veins draining these areas are occluded by thrombotic material

"The lumen of the mucocele contains cellular debris, leukocytes and mucus. In places, it is filled with old granulation tissues arising in the stroma of the mucosa. The latter contains numerous cholesterol crystals surrounded by macrophages and multinucleated giant cells.

"The cause of this mucocele is not apparent in the sections. Diagnosis: Mucocele in state of old and recent inflammation."

DISCUSSION

Osteolytic lesions of the calvarium will often pose diagnostic problems which can only be answered after a careful correlation of the clinical, roentgenological, and pathological aspects of the case.[10] Too often one is inclined to accept the pathological report as representing the final diagnosis, completely ignoring other important factors. The final diagnosis in 2 of the 3 patients presented here was made only after many consultations in which the histories, the roentgenograms and the microscopic sections were reviewed.

The case of the carotid body tumor was not correctly diagnosed until recently. The patient was first seen in another institution in December, 1938, with a left Horner's syndrome, a left frontal mass, and a mass in the left side of the neck in the region of the left carotid bulb which had been present all his life. A diagnosis of carotid body tumor with metastasis to the frontal area was suggested. He subsequently went to another hospital where the carotid ligation was performed for the supposed arteriovenous aneurysm. At the time of admission

to the University Hospital, the frontal mass was so large that the left eye was completely closed. There was a mass on the left side of the neck but its significance was not suspected.

Carotid body tumors have been variously known as endotheliomas, peritheliomas, neuroblastomas, sympathoblastomas, pheochromoblastomas, pheochromozythomas, angiomas, fibroangiomas, angiosarcomas, perithelial hemangiomas, sympathetic nevi, hamartomas, adenomas, hyperplasia of the carotid gland, paragangliomas, and simply as carotid body tumors.

The confusing terminology is undoubtedly the result of the presence in the carotid body of vascular, neural and fibrous tissues. The capillaries appear almost sinusoidal, being thin-walled and of large diameter. Anastomosing cords of cell groups are in intimate relation with the circulation. There is also a rich nerve supply.[4]

The carotid body, while not necessary for life, does have an important physiological role. It produces an effect on respiration and circulation due to the presence within the gland of chemoreceptors which respond to chemical changes in the arterial blood.[4]

The symptoms produced by these tumors are those of pressure on neighboring structures and consist of hoarseness, cough, dysphonia, dilatation or constriction of the pupil with or without narrowing of the palpebral fissure, nausea, vomiting, tachycardia, abdominal pain, constipation (vagus pressure), tinnitus aureum, headache, local pain or pain in the arm or shoulder, dyspnea or dysphagia.

The diagnostic triad[1] which helps in identification consists of (*a*) location at the crotch of the carotid, (*b*) sense of pulsation in the tumor due to its vascularity, and (*c*) the mobility of the tumor from side to side, but not up and down. In addition, the tumor is usually slow-growing, some having been reported present for as long as thirty five years. Several cases have been bilateral.[7,11,12]

Up to 1943, 250 cases of tumors of the carotid body had been reported.[5] About 20 per cent of these lesions are locally malignant, showing variation in the size of the cells, the presence of mitoses and invasion of the tumor capsule. According to extensive reviews of the subject, there has been but one proved case of distant metastases, and that was solitary to the liver.[5,12] The case presented in this report showed multiple metastases to bones, liver, lungs and the iliac vein. It was the presence of these metastases which at first cast doubt upon the revised diagnosis because of its rarity.

Carotid body tumors are apparently radioresistant. Roentgen therapy had no effect upon the metastatic tumor of the frontal bone in this patient. Phelps, Case and Snyder[11] reviewed 159 histopathologically verified cases, 7 of which received roentgen or radium treatment with no apparent benefit. Stewart[13] treated a case with 10,080 mg-hr. of interstitial radium with a temporary decrease in size, followed by continued growth. Bevan and McCarthy[1] reported that a tumor the size of an English walnut almost entirely disappeared thirteen months after fourteen roentgen treatments. The dosage and factors employed are not stated. The diagnosis of a carotid body tumor in this instance was made at operation and not verified histopathologically.

The roentgenograms in our case revealed an osteolytic lesion of the frontal bone which showed definite long, irregular bone spicule formation. In the absence of any knowledge of a primary lesion elsewhere one would have to consider meningioma, osteogenic sarcoma and metastatic malignancy among the diagnostic possibilities. As has been emphasized previously, the diagnosis in such cases is established only by the correlation of clinical, roentgenological and pathological findings. It is of interest that roentgenographically the lesion is practically identical with the meningioma in Case 11.

The *meningioma* was originally believed by some members of the Department of Radiology to represent a case of the rather

uncommon osteolytic type of osteogenic sarcoma because the appearance was similar to that found in the patient with metastatic carotid body tumor. It is to be recalled that this case was originally diagnosed as angiosarcoma. The long irregular bony spicule formation is different from that observed in most meningiomas where the bone spicules are regular and seldom measure over 2 cm. in length. In this case some of the spicules were 4 cm. long.

Histopathologically, this tumor was classified as a malignant fibroblastic meningioma, a variety which is encountered relatively infrequently. Of 306 cases of meningioma studied by Cushing and Eisenhardt,[2] 6 cases were of this type. Of the eight groups reported by them, this represents their most unfavorable type, the longest survival being two and one-half years. The case discussed in the present paper was under observation for twenty-seven months, exophthalmos and suspected bone destruction being evident on the first examination.

The case of the mucocele is of interest because of its long history, its wide extent, and the clinical impression that the lesion was a meningioma of the sphenoid ridge when the patient was first seen.

A mucocele has been defined[3] as an accumulation and retention of a mucous secretion within an accessory sinus, generally associated with a distention of one or more of its walls. It is frequently merely a retention cyst. It may be due to closure of the nasofrontal duct, trauma, or be associated with exostoses.

Mucoceles represent a relatively uncommon condition. Up to 1924, Howarth[7] collected 300 cases. McNally, Steuart and Childe[8] estimate that anyone connected with the otolaryngologic clinic of a teaching hospital would see from 5 to 10 cases in his lifetime.

The disease is essentially a condition found in younger individuals, the great majority occurring between thirteen to thirty years of age. It is most common in the frontal and ethmoid sinuses, occurs less commonly in the maxillary sinus, and rarely in the sphenoid sinus. Clinically, it is characterized by its long duration, insidious development, lack of insistent symtoms, and distention of cavities. In lesions involving the frontal or ethmoid area one usually finds a slow-growing non-tender tumor in the medial third of the eye with displacement of the globe downward, forward and laterally. The swelling does not present the usual signs of inflammation and may be mistaken for a new growth or one of the chronic granulomata. The absence of pain is a characteristic feature, although pain may be present.

The fluid contents of a mucocele are thicker than the ordinary sinus mucus, and are tenacious in character. The color may be yellow, pink, gray, or gray with black or red streaks. The contents may become secondarily infected. When grossly purulent the lesion is known as a pyocele.

Histopathological examination may reveal mucus, cholesterin crystals, degenerated epithelial cells filled with fat, and polymorphonuclear leukocytes.[14] Chemically the material contains much mucin, albumin, protein, cholesterin and fat.

Roentgenographically one observes enlargement of the sinus with pressure erosion of the walls, resulting in increased radiolucency.[6] The periphery of the bone defect is often quite dense due to new bone formation. The cyst-like swelling may destroy the bone anteriorly and posteriorly and even expose the dura.[9] If the mucocele remains untreated, as in this patient, large areas of bone destruction occur and the lesion encroaches upon adjacent structures and even causes marked exophthalmos.

SUMMARY

The clinical, roentgenological, and pathological findings in three patients with osteolytic lesions of the skull are presented. The underlying lesions were a metastatic carotid body tumor, a meningioma and a mucocele. All of these patients had certain similar physical findings, such as exopthalmos. The various studies are discussed in

detail, in an effort to emphasize differential diagnostic criteria.

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Vol. 57, No. 4

PRIMARY BRONCHOGENIC CANCER MISTAKENLY DIAGNOSED AS PULMONARY TUBERCULOSIS

CASE REPORTS WITH BODY SECTION ROENTGENOGRAPHY

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IT IS well recognized that primary bronchogenic cancer is frequently confused with pulmonary tuberculosis. Nevertheless, still too often do we see instances of bronchogenic cancer mistakenly diagnosed as chronic lung infection. With the urgency that exists to establish early diagnosis in this condition, any method which will assist in achieving this end should be more fully utilized.

During the past nineteen years, among 11,752 patients admitted to the Olive View Sanatorium, 16 cases of proved primary bronchogenic carcinoma have been diagnosed, giving an incidence of 0.14 per cent. With the exception of one case, an employee, all had been diagnosed before admittance as definite or probable pulmonary tuberculosis.

A study of these cases after admittance showed the ratio of females to males to be 1:2.2, which is higher than Vinson's[1] ratio of 1:3.6 or Adams'[2] ratio of 1:4.4. The symptomology and physical signs of cancer of the lung closely simulate those of pulmonary tuberculosis and are for this reason misleading. Two-thirds of those tested with tuberculin were negative. This indicates the prime importance of this simple test which becomes more valuable as the incidence of positive tuberculin skin test in the general population decreases. The sputum was negative for tubercle bacilli in all 16 cases. There had been a history of positive sputum in 2 cases before admittance. One of these proved to have not only a negative sputum, in the Sanatorium, but a negative skin test as well, and it must be presumed that either the sputum report was erroneous or that the organisms were non-pathogenic bacilli. In another case, pulmonary tuberculosis was found at autopsy, in addition to carcinoma, with an epithelialized cavity. The sedimentation rate, and the white blood cell count were similar to those found in tuberculosis. Secondary anemia was present in nearly every case.

Pleural effusion was present in 6 cases. The fluid was negative for tubercle bacilli. In 1 case, tumor cells were found in the fluid. No blood cells were found in any of the cases.

Direct visualization of the bronchial tree maintains its unchallenged position as a means of diagnosis and determining the extent of involvement of the major bronchi in bronchogenic cancer. Chevalier Jackson has stated that 75 per cent of bronchogenic carcinomas can be visualized through the bronchoscope. Only half of our pateints were bronchoscoped; positive diagnosis resulted in 5 out of the 8. While it is not practical or necessary to bronchoscope all patients diagnosed as tuberculous, still in patients with a negative sputum and particularly a negative tuberculin reaction, with pulmonary pathology consistent with cancer of the lung by roentgen examination, or in cases without roentgen evidence of pathology in the presence of hemoptysis, bronchoscopy should be done forthwith. Another indication for bronchoscopy is pulmonary wheeze. Clerf[3] has pointed this out as a rather early clinical symptom often overlooked or disregarded by both patient and physician. This is also a relatively common symptom in pulmonary tuberculosis, although usually a later development, secondary to cavitation. The importance of

Fig. 1. Case 1. Conventional roentgenogram of case of bronchogenic carcinoma of the left upper lobe bronchus with distal atelectasis.

bronchoscopy in the presence of this symptom lies in the possibility of differentiation both by reason of the appearance of the bronchial lesion and by means of culture of aspirated secretions for tubercle bacilli, and microscopic examination for malignant cells in biopsy section or in aspirated secretions or washings from the bronchial tree. Fixation or compression of a bronchus may suggest the location of a tumor even though it cannot be seen directly. Negative bronchoscopic findings in the presence of roentgenographic evidence favoring malignancy does not, of course, rule out the presence of bronchogenic cancer.

The conventional roentgenographic appearance of bronchogenic cancer has been described many times. Briefly, it consists, in the early case, in a dense nodule or mass, usually in the perihilar regions; whereas in tuberculosis the early lesion is usually found in the subapical or apical region. Lobar atelectasis, although usually considered a late development, occurs, according to Olds and Kirklin,[4] with the same frequency as unilateral infiltration. In tuberculosis, atelectasis occurs in association with a bronchial lesion, but this is practically always a late development and there is nearly always some tell-tale infiltration in some other lobe.

The less common peripheral type of tumor and the still rarer "superior pulmonary sulcus tumor" of Pancoast present clear-cut, rounded or oval outlines. The similar "round foci" of tuberculosis are usually multiple and often associated with nodular, or other types of infiltration.

In the growth and development of any of these tumors, there is extension into the surrounding lung tissues and necrosis, with abscess formation, often with pleural effusion. Roentgenographic differentiation from tuberculosis in this stage is often difficult unless there is evidence of bone destruction.

Body section roentgenography, though no longer a new procedure, has been used chiefly in the study of pulmonary tuberculosis. From the information gained by the use in this method in the last 4 of our 16 cases, we are convinced that this type of roentgen examination represents a significant advance in the roentgenographic diagnosis and study of bronchogenic carcinoma.

CASE REPORTS

Case 1. J. B., male, aged forty-seven, felt "under par" about one year before admittance. Four months before admittance he developed a cough, night sweats, and fever. Pneumonia was diagnosed and he was admitted to a hospital for six days. After returning home he continued to have mild fever and remained in bed. One month later, roentgen examination revealed dense involvement of the left upper lobe, and a diagnosis of pulmonary tuberculosis was made. His sputum was negative for acid-fast bacilli, and no tuberculin test was made. After three months' rest at home, he applied for admittance to the Olive View Sanatorium.

Physical examination on admittance revealed a well nourished man, with a productive cough and a maximum temperature of 99.2°F. There were a few moist medium râles over the left upper lobe. The left lower lobe was hyperresonant.

The white blood cell count was 9,200; vital capacity 2,400 cc. (55 per cent); sedimentation time forty three minutes (Linzenmeier), and hemoglobin 82 per cent. The tuberculin test was 1 plus in dilution of 1:10,000; the coccidioidin test was negative. All sputum examinations including sputum and gastric cultures, were negative for tubercle bacilli.

The conventional roentgenograms, during a four month period, showed a dense left upper lobe, with some very indefinite highlighting through this area, suggesting the possibility of cavitation (Fig. 1). No definite mass could be differentiated from the upper lobe density.

The patient continued to have a slightly productive cough, raising 1 to 4 ounces of sputum daily, with no blood streaking. Slight fever continued but the patient gained 17 pounds in six months. An unsuccessful attempt was made to outline the left upper lobe with lipiodol. However, during the bronchoscopic examination a mass could be seen partially obstructing the left upper lobe bronchus, and a biopsy was done. Planigrams made at this time revealed a distinct mass involving the wall of the proximal portion of the left upper lobe bronchus, extending from the lateral wall around to the mesial wall (Fig. 2), and involving the distal upper part of the left main bronchus (Fig. 3). The mass extended down the lateral aspect of the left lower lobe bronchus for a short distance. The lumen of the upper lobe bronchus, through the involved area, was tortuous and narrow. The upper lobe was atelectatic and there were numerous circular and oval bronchiectatic dilatations.

The microscopic examination of the biopsy specimen revealed a poorly differentiated anaplastic bronchogenic carcinoma, made up chiefly of small round cells. There were many mitotic figures.

Fig. 2. Case 1. Planigram (8 cm.) of left lung showing dense mass involving the walls of the left upper lobe bronchus, making the lumen stenotic and tortuous. Numerous bronchial dilatations are seen in the atelectatic left upper lobe. The left main bronchus is not seen at this level.

Fig. 3. Case 1. Planigram (9.5 cm.) showing the rough and uneven character of the upper distal wall of the left main bronchus. This extension was confirmed at operation when the left main bronchus was cut through.

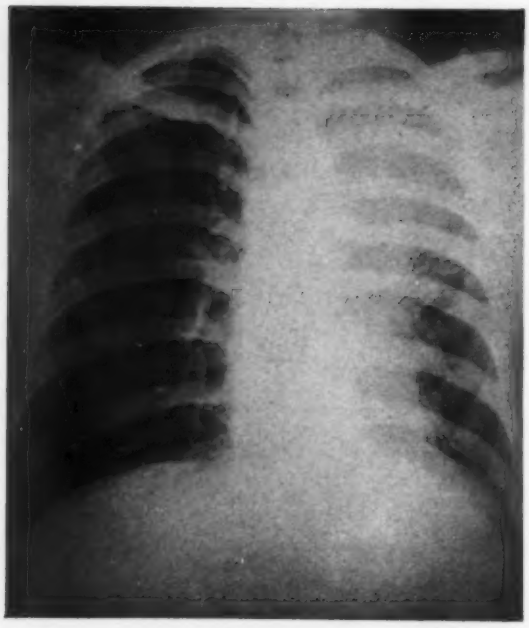

Fig. 4. Case II. Conventional roentgenogram of case of bronchogenic carcinoma of the left upper lobe bronchus. The left upper lobe is dense due to atelectasis.

This patient was transferred to the Los Angeles General Hospital where pneumonectomy was performed. Unfortunately, the patient died two days later of cardiac complications. Sections of the lung and bronchi indicated that the findings revealed by the planigrams represented a true picture of the location and extent of the tumor, and of the secondary atelectasis and bronchiectatic involvement of the left upper lobe.

Case II. A. McC., male, aged thirty-one. Onset nine months before admittance with hoarseness and loss of weight. Patient consulted an otolaryngologist who did a bronchoscopic examination and had roentgenograms of the chest made. Bronchogenic cancer was suspected and five deep roentgen treatments were given with no demonstrable effect. The patient then consulted another physician who referred him to a chest clinic where his sputum was reported to be positive for tubercle bacilli. He was then admitted to a private sanatorium where no tubercle bacilli could be found, even by gastric lavage studies. The pulmonary condition was diagnosed as tumor and the patient was discharged. He once more attended the chest clinic and because of the previously reported positive sputum he was admitted to the Olive View Sanatorium.

The patient was in a fair physical condition, except for a weight loss of 14 pounds, and the only symptom was hoarseness. Indirect examination of the larynx showed paralysis of the left vocal cord. The hemoglobin was 80 per cent; vital capacity 3,500 cc. (80 per cent), and the sedimentation time forty-five minutes. Three sputum concentrations, and one gastric lavage specimen were negative for tubercle bacilli, microscopically and by culture.

The conventional roentgenogram of the chest revealed an appearance strikingly similar to that in Case I, except that the left upper lobe showed no aeration whatever (Fig. 4).

Planigrams were made immediately. The left upper lobe was atelectatic and contracted. A mass was seen involving the lateral wall of the upper lobe bronchus, extending around to the mesial wall of this bronchus (Fig. 5). The lumen of the upper lobe bronchus was more completely blocked than in Case I. No air could be seen in this bronchus beyond a distance of 1 cm. from its bifurcation from the left main bronchus. There were no bronchiectatic dilatations in the left upper lobe. The left main bronchus was clear-cut and smooth throughout indicating no gross invasion (Fig. 6). Based on these findings, a diagnosis of probable bronchogenic cancer was made.

Two bronchoscopic examinations were made but no tumor mass could be seen in either examination. The left main bronchus was smooth and normal in appearance. The opening of the left upper lobe bronchus could be seen but no narrowing of the bronchus could be seen. However, because of the roentgen findings an attempt was made on both examinations to secure a biopsy specimen at the opening of the left upper lobe-bronchus. However, both specimens showed only normal bronchial wall tissue.

The patient was transferred to the Los Angeles General Hospital for an exploratory operation. However, before the operation could be performed the patient developed symtoms of diabetes insipidus which were believed to be due to cerebral metastasis, and surgical intervention was not deemed advisable. The patient died three months after discharge and autopsy showed bronchogenic carcinoma in the location and extent indicated by the planigrams and, in addition, general metastases.

DISCUSSION

It is clearly recognized that the final definite diagnosis of bronchogenic cancer can only be made by microscopic examination of tissues showing malignant cells. This tissue may be secured by bronchoscopy and biopsy of the bronchial lesion, or in more advanced cases by biopsy of a metastatic gland, by punch biopsy, bronchial washings, or examination of sputum, or pleural effusion for malignant cells. Nevertheless, the roentgenologist carries the responsibility of keeping in mind the possibility of cancer and of suggesting it to the clinician. This suggestion must arise out of the sum total of the evidence afforded by the roentgenographic examination. This evidence can be very materially increased by the use of body section roentgenography. Many details concerning the position, form, and extent of the tumor mass, as well as its relation to intrathoracic structures can be shown by this method with a degree of exactness not possible by conventional roentgenographic methods. The tumor mass can often be differentiated from the shadow caused by atelectasis as well as shadows resulting from overlying and underlying structures. The detailed appearance of the tumor can thus be studied more exactly. The portion of the bronchial tree involved and the extent to which neighboring parts of the bronchial tree have been invaded are often strikingly demonstrated. The degree

FIG. 5. Case 11. Planigram (8 cm.) showing the tumor involving the lateral and mesial walls of the proximal portion of the left upper lobe bronchus. The lumen in this region is completely blocked. This tumor could not be seen bronchoscopically.

FIG. 6. Case 12. Planigram (9 cm.) shows the entire left main bronchus to be smooth with no evidence of gross invasion.

of stenosis of the bronchus is well shown, especially in early cases. Invasion of the surrounding parenchymal lung tissue is much more readily demonstrated by sectional roentgenograms as well as the presence of central necrosis. The character of the cavity wall, as shown by sectional roentgenograms, is of importance in differentiation from tuberculous cavities and lung abscesses. In the cavity, formed by necrosis of a malignant tumor, the walls are jagged and irregular, whereas other cavities are more rounded or oval, and smooth walled.

From this limited experience, it is felt that, wherever possible, suspected cases of bronchogenic cancer should have the advantage of an examination by body section roentgenography, in addition to the conventional roentgenographic examination.

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Vol. 57, No. 4

THE VALLECULAR SIGN

ITS DIAGNOSIS AND CLINICAL SIGNIFICANCE*

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THE inclusion of the pharynx in the routine stomach examination has been advocated by Chevalier Jackson and others. It was during routine intestinal tract examination that we observed a roentgenological phenomenon which we propose to name the "vallecular sign," as it is in our opinion of considerable diagnostic value. It consists of the retention of barium mixture during the swallowing act in the pockets of the valleculae and in the pyriform sinuses. It is of special interest that the phenomenon occurred not only in such affections of the swallowing act as bulbar paralysis and myasthenia gravis, where it is known and expected, but also in pathological processes which have their origin and location at a considerable distance from the pharynx.

A review of the literature shows that the first description of the frequently overlooked or neglected phenomenon is, as far as we could trace it, the one by Pannewitz who in 1931 described its occurrence in several cases of esophageal carcinoma. It is not, however, a pathognomonic sign of esophageal malignancy and might occur, as our cases demonstrate, in carcinoma of the cardia as well as of the hypopharynx, the esophagus, and in other pathological conditions of the mediastinal and paramediastinal structures; it occurs further in myasthenia, bulbar paralysis, and multiple sclerosis. We have not as yet observed it, however, in neurotics complaining of dysphagia, and thus it might be taken as a differential diagnostic sign pointing to organic disease.

If we observe the normal act of deglutition under roentgenoscopy, we find the sequence of movements so rapid that they cannot be properly analyzed, since the barium is propelled into the upper esophagus in but one short contraction. The spot roentgenogram studies and serial roentgenograms of Barclay have analyzed the act of swallowing in a healthy person as:

(1) The movement of the tongue towards the posterior pharyngeal wall.
(2) The rise of the larynx due to contraction of the mylohyoid and stylohyoid muscles.
(3) The obliteration of the pharyngeal space for a fraction of a second.
(4) The compression and propulsion of the bolus into the opened pharyngeal space.

The question as to whether the entire swallowing act is one of coordinated pressure, as assumed by the older investigators (Magendie, Kronecker) or whether it is suction into the negative space is as yet not decided. Barclay holds that negative pressure created at the time of closure of the pharynx is the main force in the propulsion, while other authors, acceding that such suction exists, deny that it is an essential factor in propulsion.

In the normal patient the barium enters the valleculae and is immediately spilled, occasionally leaving, however, small traces (not to be mistaken for a positive vallecular sign) which consecutive swallowings clear out. The epiglottis which remains upright during swallowing divides the barium into equal parts and passes it along the lateral walls into the pyriform sinuses. It is, therefore, with proper methodic and spot device, easy to obtain in a normal person a picture which shows the valleculae and the pyriform sinuses filled, although only for a very short time. Failure of one of the recessus to fill constitutes, in the opinion of

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† Dr. Wolf died on December 17, 1946.

Barton R. Young, disease, usually a neoplasm in the recessus, frequently revealed on the same roentgenogram by a filling defect or a soft shadow.

The vallecular sign is the opposite of such observations: not failure, but retention of the barium within the recessus for a relative long time.

It is found first and foremost in paralysis of the pharyngeal muscle of peripheral or central origin and this is very easily explained. The larynx is not raised sufficiently; the pharyngeal space is therefore not obliterated during the swallowing act. The contrast meal, as a consequence, is not pressed actively but rather glides along the dorsum of the tongue into the presenting pockets of the valleculae, and when they are filled the barium sinks into the second receptaculum, the pyriform sinus, and there is not enough constricting force to empty the basin.

These deviations from the normal course of events are seen in roentgenograms and can be analyzed in kymograms of the swallowing act. In myasthenia gravis the roentgenological observation has been developed into a diagnostic test. If the recessus empties after administration of prostigmine methylsulphate (1:2000) it is taken, in the opinion of some authors, as a sign pathognomonic of myasthenia gravis. Schwab and Viets hold that such prompt prostigmine response does not occur in bulbar paralysis.

We have used the observation of the improvement of deglutition, as evidenced in

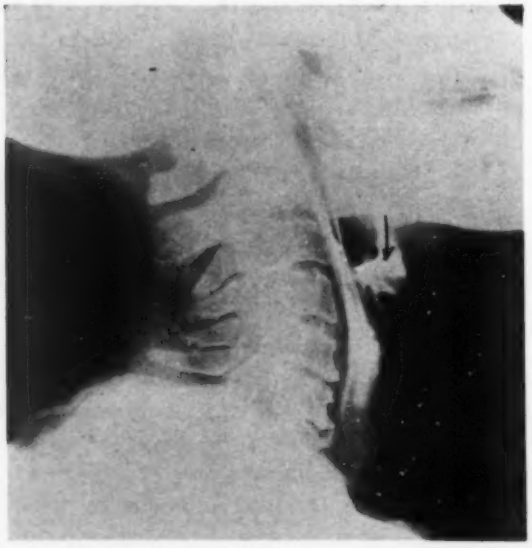

Fig. 1

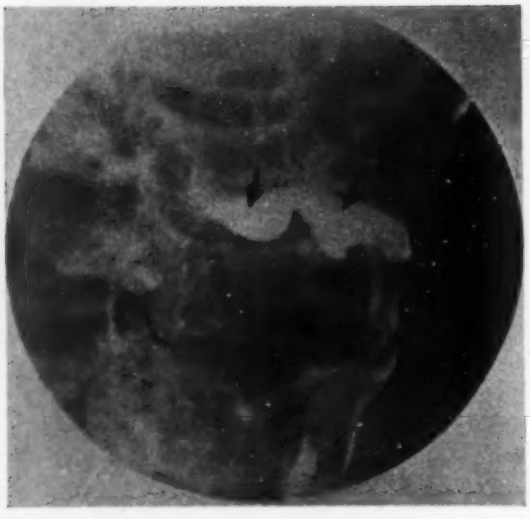

Fig. 2

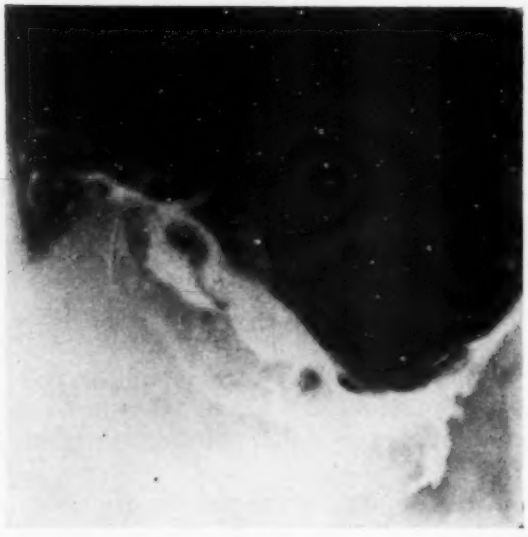

Fig. 3

Figs. 1–3. Case 1. Retention of barium in valleculae and pyriform sinuses in a case of carcinoma of the cardia without any other sign of stenosis or paresis.

the emptying of the valleculae and recessus, as a measure of therapeutic efficiency after thymus irradiation.

While in bulbar paralysis the disturbance of deglutition was most marked and quite characteristic, a differentiation of the vallecular retention as it occurs in myasthenia gravis and in various malignancies was not possible. We observed the positive vallecular sign, as we like to call it, in various other conditions and report here our findings in 2 cases of carcinoma of the cardiac end of the stomach, 1 case of hypopharynx carcinoma, 1 case of suspected paramediastinal lung tumor, 1 perforating carcinoma of the esophagus, and 1 case of special interest of dysphagia lusoria due to a vascular abnormality.

We have learned to consider the presence of the positive vallecular sign at the onset of our examination as an indication for especially careful examination for neoplasm, or serious mediastinal pathology.

CASE REPORTS

Case 1. L. B., white, male, aged sixty-nine; admitted to the hospital on August 31, 1944.

Fig. 5

Fig. 6

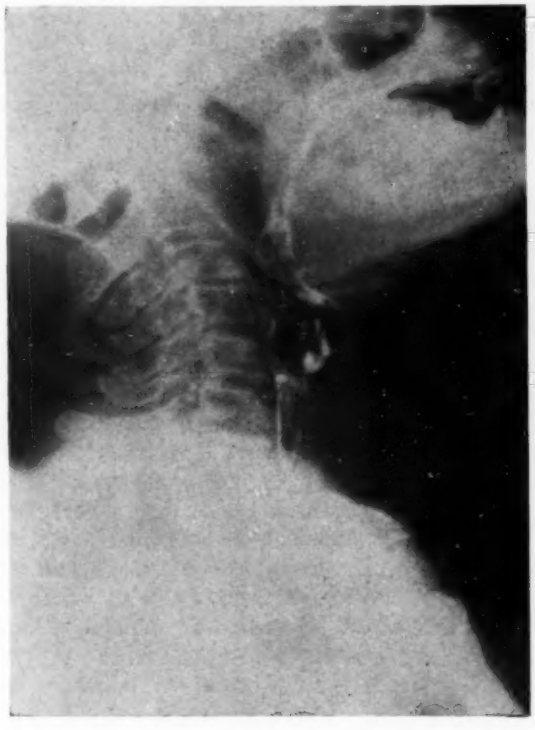

Fig. 4

Figs. 4–6. Case II. Positive vallecular sign in a case of carcinoma of the cardia.

Fig. 7. Case III. A case of hypopharyngeal carcinoma reveals retention of both valleculae and pyriform sinuses. Hyoid bone did not ascend in deglutition.

Patient complains of progressive weakness for several months, loss of weight 20 to 30 pounds within a year. Complains also of sensation of fullness, dysphagia, and epigastric pain following meals. No belching, burning, hunger feeling. For past two months stools somewhat black, constipation for one year. Patient has subcostal pain following ingestion of food.

Review of systems negative. Abdomen: Indefinable mass present in epigastric region. Patient appears emaciated and chronically ill. Serology negative. Electrocardiogram negative.

Roentgenological Examination. Barium retained in the valleculae and pyriform sinuses; extensive carcinoma of the cardia; no operation; patient discharged.

Comment. This case demonstrates a positive vallecular sign in an extensive carcinoma of the cardia without any other signs of stenosis or paralysis.

Case II. W. F., white, male, aged seventy, readmitted to the hospital on March 4, 1945, had a recent prostatectomy. While recovering from the operation he complained increasingly of substernal pain which was first diagnosed as coronary insufficiency. He described his pain as a pressing sensation, intermittent, lasting approximately one hour. He also had pain in his back radiating into the lumbar area; frequently night pain. Twenty minutes after eating he had severe lower abdominal pain.

The systematic check-up revealed a soft systolic murmur throughout the precordium, best heard over Erb's point.

Palpation revealed no masses in the abdomen.

Electrocardiogram showed left ventricle preponderance; T_4 negative.

Roentgen examination revealed retention of barium in the valleculae and pyriform sinuses, and carcinoma of the cardiac region of the stomach extending into the lower esophagus.

Comment. Positive vallecular sign in a carcinoma of the cardiac region of the stomach.

Case III. J. B., white, male, aged eighty, admitted to the hospital on September 28, 1944. Patient complains of gurgling in throat when taking fluids; chronic cough; dysphagia, belching. He was fairly well until seven weeks ago when he developed these signs. There was no hoarseness and no weight loss.

Review of Systems. Normal with the exception of the liver edge being palpable and left scrotal hernia. Post-rhinoscopic and laryngeal examination were impossible due to lack of cooperation. The larynx and trachea were not fixed and no masses were palpable. Wassermann reaction negative.

Blood count: 3,350,000 red cells and 7,650 white cells; hemoglobin 82 per cent.

Blood in stool, 4 plus.

Roentgen Examination. Barium remained in hypopharynx, valleculae, and sinuses. Barium passed farther down only after swallowing several times. The esophageal passage was not impaired. On one of the roentgenograms some overflow into the trachea was seen. There was no sign of a fistula, but a large protrusion of the posterior wall of the hypopharynx with an irregular break of the barium in this region. The stomach was normal with a very large gas accumulation in the cardia.

Diagnosis: Hypopharyngeal carcinoma.

Comment. A case of hypopharyngeal carcinoma. The first complaints were dys-

phagia and gurgling in the throat and sensation of mass in throat. Markedly positive vallecular sign; pyriform sinuses also remained filled. Overflow into the trachea. Hyoid bone did not ascend in swallowing act and there was, due to fixation, no disappearance of the potential pharyngeal space.

Case iv. H. L., white, male, aged sixty-two, admitted to the hospital on May 24, 1944, complaining of weight loss and increasing dysphagia.

The roentgen examination showed immediately after the first sip of barium a retention of barium in the pharynx with barium retention in the valleculae and pyriform sinuses, and further observation demonstrated the narrowing of the esophagus in its upper and middle portion.

Inspection of the larynx revealed a mass in the pyriform sinuses with paralysis of the left cord, originating from the posterior pharynx wall and aryepiglottic folds.

Autopsy Report. (Dr. I. Davidsohn). The right pyriform fossa and the hypopharynx show a friable infiltrating tumor mass 5 by 3 cm. The larynx is not directly involved. Another ulcerated tumor 5 by 4 cm. was present in the esophagus reaching down to 7.5 cm. above the cardia. The tumor penetrated anteriorly into the mediastinum below the bifurcation of the aorta. Two fine nodular elevations of carcinoma are also found in the mucosa of the anterior wall of the esophagus.

Comment. Unilateral vallecular sign due to extensive hypopharyngeal and esophageal carcinoma.

Case v. B. K., white, male, aged sixty, admittted to the hospital on April 21, 1945, complaining of a hacking cough for six weeks, worse at night. He had to give up working. Had a dull feeling in the chest at the lower end of the sternum; appetite poor, loss of 14 pounds; great weakness.

Physical examination showed a mass at the episternal notch which was not movable by deglutition.

Roentgen Examination. There was marked barium retention in valleculae and pyriform sinuses. As the barium filled the esophagus a fistula was found opening into an irregular shadow in the right mediastinum and the hilum of the lung indicative of an esophageal carcinoma with penetration into the mediastinum. Upper mediastinum widened due to enlargement of glands.

Fig. 8. Case iv. Positive unilateral vallecular sign and filling of pyriform sinuses in a case of hypopharyngeal and esophageal carcinoma.

Patient died on April 24, 1945.

Pathological Report (Dr. I. Davidsohn). Carcinoma of the esophagus perforating into the mediastinum and the right main bronchus with hemorrhage into the gastrointestinal tract and aspiration of blood. Carcinomatous infiltration of the neck.

Comment. Presence of a marked vallecular sign and retention in pyriform sinuses found in a case of esophageal carcinoma with perforation into the mediastinum and bronchus.

Case vi. H. W., white, male, aged sixty, a printer, admitted to the hospital on August 18, 1943, with a history of prostatic complaints of one year's duration. Complete retention; hematuria.

Operation. Suprapubic prostatectomy. Following operation rapid pulse of 140, falling blood pressure. Three days after operation patient complained of difficulty in swallowing and

Fig. 9

Fig. 10

pain between scapulae. Upon drinking a glass of orange juice he complained of difficulty in swallowing. Physician suspected diverticulum of the esophagus. Roentgenogram negative, positive vallecular sign.

Re-examination on December 25, 1944. After a recent strain while working an elevator, patient developed pain in the chest and breathlessness. The heart is slightly enlarged to the left.

Electrocardiogram shows changes compatible with myocardial infarct.

Roentgen examination of the chest with lipiodol demonstrates an infiltrating area underneath the right horizontal middle bronchus suggestive of a primary or secondary lung tumor, probably carcinoma.

Comment. Positive vallecular sign repeatedly found in a patient who complained of dysphagia. Only definite clinical diagnosis, myocardial infarct.

Roentgenologic examination shows a round, paramediastinal shadow in the lung. Malignancy suspected yet not proved.

Case vii. R. O., white, male, aged forty-six, admitted to the hospital on May 3, 1941, complaining of hoarseness and inability to swallow; noticed that for the last month he has at times difficulty in swallowing, first in swallowing liquids, later on also of solids. Two days previously he wanted to drink some orange juice, but was unable to swallow it. He has no pain, only hoarseness. For two days he had also numbness and loss of sensation to touch in the right arm.

Examination of Systems. Paralysis of the left vocal cord; paresis of the soft palate. Otherwise normal.

Neurological Examination. Lack of sensation and temperature in the right hand; sluggish reaction of the pupils.

Serology was negative.

Roentgen Examination. Typical picture of barium retention in valleculae and pyriform sinuses.

Clinical Diagnosis. Bulbar paralysis; occlusion of the posterior inferior cerebellar artery. Wallenstein syndrome.

Figs. 9–10. Case v. Presence of a marked vallecular sign in an esophageal carcinoma in its middle third with perforation.

Fig. 11

Fig. 12

Figs. 11–12. Case vi. Dysphagia. Diverticulum clinically diagnosed, but no roentgenological evidence. Positive vallecular sign and bronchial elevation demonstrated. Lung tumor suspected.

Fig. 13

Fig. 14

Figs. 13–14. Case vii. Positive vallecular sign in patient with dysphagia due to bulbar paralysis.

Fig. 15

Fig. 16

Comment. Positive vallecular sign in patient with dysphagia due to bulbar paralysis.

Case viii (courtesy Dr. B. Pearlman). S. G., white, male, aged fifty-five, admitted to the hospital on March 24, 1941, complaining of orthopnea and paroxysmal dyspnea lasting one

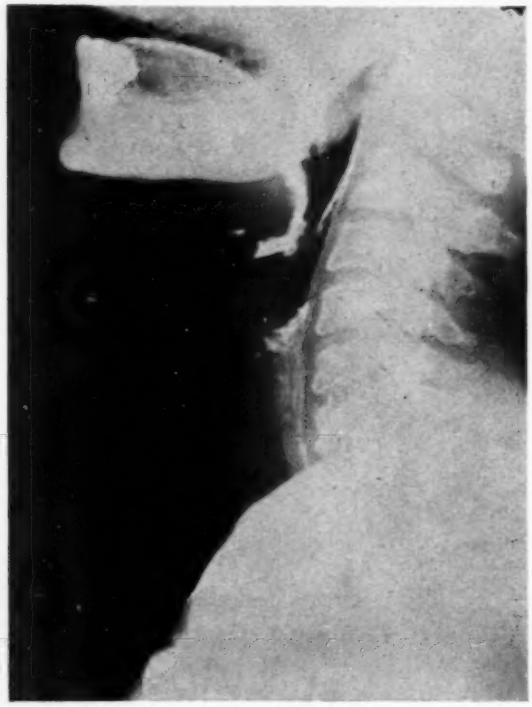

Fig. 17. The vallecular sign in myasthenia gravis.

to twenty-four hours at a time. A coronary attack was observed one month prior to admission. Coronary damage was found on electrocardiogram following an attack observed one week prior to admission.

Physical Examination. Heart enlarged to the left; impaired resonance and moist râles over both bases. Liver slightly enlarged; edema of ankles.

Roentgen Examination. Roentgenogram of the chest showed marked enlargement of the

Figs. 15–16. Case viii. Persistent vallecular filling and sinus pyriformis filling in a case of abnormal origin of the subclavian artery with symptoms of dysphagia lusoria.

left ventricle; the right heart, too, shows considerable enlargement; moderate sclerosis of the aorta; stasis over the pulmonary vessels. Examination of the esophagus reveals disturbance of the swallowing act; barium retained in valleculae and pyriform sinuses, not cleared by several swallowings. Esophagus normal.

Clinical Diagnosis. Coronary disease with recent occlusion; nephritis; bronchopneumonia; chronic degenerative heart disease.

Abstract of Autopsy. Heart size 13 by 12.5 cm.; eccentric hypertrophy; thrombotic occlusion of a branch of the anterior left coronary artery; acute myomalacia of the left ventricle; old healed infarct of the left ventricle; mural thrombosis.

Aorta: Abnormal origin of the right subclavian artery. The right common carotid artery originates directly from the aorta and divides after a course of about 3 cm. in its two branches (the left common carotid and subclavian artery are normal in their origin). About 1 cm. below the left subclavian artery on the posterior circumference of the terminal portion of the arch originates a large artery about 8 mm. in diameter. It runs towards the right between the esophagus and the spinal column and follows the course of the right subclavian artery. At the point of its origin there is a small diverticulum of the aorta. The esophagus is enclosed in the already mentioned loop formed by the arch of the aorta and the abnormally originating right subclavian artery.

Comment. A positive vallecular sign and disturbed deglutition found in a case of abnormal origin of the right subclavian artery with clinical symptoms of dysphagia lusoria.

DISCUSSION

The symptom common to these varied pathological processes is dysphagia. The clinical term is alternately used to describe difficulties in swallowing as well as pain along the esophagus. Dysphagia occurs in organic and functional disease. To differentiate between them, first in a general and later in a specific way, frequently taxes the physician's ingenuity. In this respect the vallecular sign, at the present stage of our investigation, is in favor of an organic lesion. The interpretation, however, should be made carefully. Some barium residue or a sluggish downward movement might also occur in older persons with atony of the pharyngeal muscle, in debilitating diseases, and in convalescence.

We have had as yet no occasion to examine a case of Plummer-Vinson's disease where dysphagia is an important and as yet obscure symptom.

The neuropathic patient presents various types of dyskinetic movements, especially esophageal cramps and contractions, but we did not observe the barium retention in the valleculae, the inhibition of the movement of the hyoid bone, and the temporary disappearance of the pharyngeal space. The combination of two or three such signs is more reliable than a slight residue and is very suggestive of an organic lesion and these observations can be registered in serial roentgenograms or even better in kymograms. The organic lesion might be a cancer of the larynx or esophagus, a mediastinal tumor and carcinoma of the lung close to the main bronchi, and aneurysm of the aorta, or certain vascular abnormalities.

The dysphagia in such processes is usually brought in connection with the stenosing character of these lesions; yet many of these cases were not of stenosing character and the symptom of dysphagia could be traced to the dyskinesia of deglutition with its repeated, strenuous efforts to empty the valleculae and the pyriform sinuses.

The cause of the faulty deglutition is commonly seen in direct involvement of the vagus nerve. As the nerve is ubiquitous, this seems convincing enough, but does not explain its occurrence in every case. The absence of other signs of vagal involvement, the sometimes early occurrence of the vallecular sign, even before the lesion of the esophagus could roentgenologically be demonstrated speaks against it. Pannewitz has described 2 such cases where the tumor was not as yet demonstrable, while the deglutition was already markedly disturbed.

The occurrence of dysphagia in compressing but not invading processes, such as

auricular enlargement and aneurysm, as described by Bloomfield, speaks also against obstruction with its origin in the esophagus, as well as against direct pressure upon the vagus nerve, which is usually free enough to escape such pressure.

Such direct nerve involvement does not seem necessary for the production of the vallecular sign. The hyoid movement during swallowing which is necessary for normal deglutition is combined with a considerable laryngeal movement as can be felt by palpation and with it is connected a certain tracheal movement. Fixation of any of these structures might be sufficient to disturb an act which is based on mobility and a high degree of coordination. It has been stated that eighteen different muscles participate in the arytenoid and vocal cord movement. Fixation results in a dyskinesia of the coordinated movement of various structures. Such fixation is, for example, observed in calcification of the stylohyoid ligament and elongation of the stylohyoid process, and this anomaly frequently causes dysphagia. Other causes might be found as our observations progress.

Of special interest to us was the occurrence of the positive vallecular sign in a case of a vascular abnormality, verified by autopsy (Case VIII), where the esophagus was enclosed in a loop formed by the arch of the aorta in the abnormally originating right subclavian artery. The dysphagia in such cases is usually termed "dysphagia lusoria," translated by White and others as a false dysphagia. It was exactly such a case of an abnormal origin of the right subclavian artery from the third part of the aorta upon which Bayford based his description of dysphagia lusoria. The description of Bayford's case can be found in Bloomfield's publication and this author has the merit of restoring the true meaning of the term as one of lusus naturae, a lapse of nature.

Our case with its positive roentgenological findings is a good illustration that the dysphagia here is a true one due to the vascular abnormality, not an illusory one.

A finer analysis of the swallowing act in roentgenograms, under fluoroscopy, and with the kymogram will be helpful in the indication of such hidden but very real disturbances of deglutition and will in many other cases permit us to differentiate between a nervous dysphagia and one due to organic or neurological reasons.

CONCLUSIONS

1. The dysphagia which accompanies many malignant growths of the hypopharynx of the esophagus and the upper stomach region is not, as commonly assumed, due to stenosis and prestenotic regurgitation, but is primarily a disturbance of deglutition.

2. The symptom of barium retention in the valleculae and in the pyriform sinuses is found in many of these cases to be an important roentgenological sign. The name "vallecular sign" should designate its clinical significance.

3. Each case of dysphagia should be examined by a barium meal and special attention paid to its presence.

4. The presence of the vallecular sign is in favor of an organic lesion and is against a functional type of dysphagia.

5. A positive vallecular sign is demonstrated in carcinoma of the cardia, of the hypopharynx, and the esophagus, also in bulbar paralysis, and in myasthenia gravis. One case of dysphagia lusoria due to abnormal origin of the right subclavian artery showed the vallecular sign as the only positive roentgenological finding.

6. The occurrence of the vallecular sign in myasthenia gravis and bulbar paralysis is helpful in the recognition of these diseases and its improvement is a good measure of the therapeutic effect of thymus irradiation.

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CONGENITAL APLASIA OF THE LUNG

A CASE REPORT*

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CONGENITAL absence of a lung is a rare condition. Recent reviews[1,2,3] obviate the necessity for further surveys of the literature in this connection; but there remains an obligation to record such anomalies in the interest of furthering a knowledge of their incidence and clinical diagnosis.

CASE REPORT

A white housewife, aged forty, was admitted to the State of Wisconsin General Hospital on September 17, 1945, complaining of "afternoon fever and weakness." The right breast, the seat of cystic changes, had been removed ten weeks previously. After a month's period of well-being, slight afternoon fever, weakness, dyspnea and undue fatigue on minor exertion had been remarked for the past five or six weeks. More recently dyspnea had developed upon lying down for continued periods. A sense of thoracic tightness had occurred from time to time. Upon direct questioning the patient admitted that she had never had the reserve strength of her childhood associates. Participation in their games and physical activities had always been limited by dyspnea.

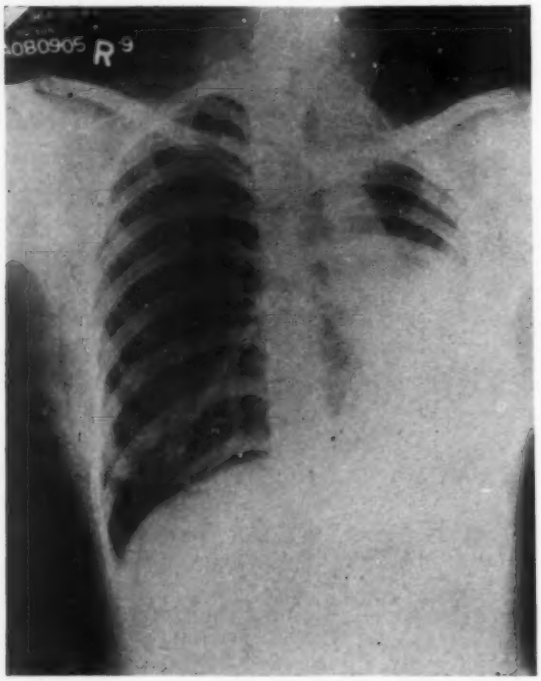

FIG. 1. Posteroanterior roentgenogram of chest showing mediastinal displacement to the left, herniation of right lung across the midline and homogeneous density obscuring left lower lung field. Cardiac margins indefinite.

The pertinent physical findings were thoracic. The trachea was sharply deflected to the left. The left hemithorax was much smaller than the right. Its movements were likewise restricted. The maximal apical impulse was located in the left axilla. Tactile fremitus was decreased to absent at the left base posteriorly. The percussion note at the left base was dull to flat. Cardiac dullness was difficult to define but hyperresonance was elicited in the normal position of the heart. Breath sounds and vocal resonance were reduced to absent over the zone of dullness in the left infrascapular region.

The impression of occlusion of the left main bronchus was gained and bronchoscopy recommended. Upon direct visualization the absence of any opening leading to the left bronchus was noted. Tissue removed from the anatomic site on the left bronchus disclosed only normal histologic findings. Repeat bronchoscopy confirmed the original observation of an absence of the carina and of the left main bronchus.

Roentgen studies revealed the following pertinent findings: Roentgenoscopic examination and posteroanterior and lateral roentgenograms of the chest showed a pronounced shift of the mediastinal structures to the left with herniation of the right lung across the midline. This displacement was more marked on inspiration. The anterior mediastinal space was very large. The heart was displaced to the left and posteriorly, and appeared to lie almost lateral to the spine. Its borders could not be clearly defined.

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At the peripheral aspect of the left lung base there was a homogeneous shadow with a sharply outlined convex inner margin. The left leaf of the diaphragm could be visualized directly beneath this, and it moved in a normal manner. Upon ingestion of a barium-water mixture the esophagus was found to be displaced to the left and posteriorly. The stomach was in a normal position and there was no evidence of a diaphragmatic hernia. Bronchography following the instillation of iodized oil demonstrated a complete stenosis of the left major bronchus about 2.5 cm. from its origin. The lumen of the bronchus narrowed down to a smooth cone-shaped point. A partial filling of the right middle and lower lobe bronchi was obtained. The middle lobe was almost entirely in the left thorax and anterior mediastinum. Only the origin of the right upper lobe bronchus could be demonstrated but this arose from the right anterior aspect of the trachea and this lobe appeared to be the one filling the upper anterior mediastinal space and the upper part of the left thorax.

Schneider[4] classified anomalous development of the lung in three groups: (*a*) true aplasia, when all traces of the lung, bronchus and vascular supply are lacking; (*b*) aplasia of the lung with a rudimentary bronchus, when the bronchus is represented by a small bulging of the trachea supported by a ring of cartilage, but lung parenchyma is absent; (*c*) extreme hypoplasia, when the bronchus is fully formed but of small caliber and ends in undifferentiated structures (sometimes primitive lung), without lobes, in the mediastinum.

Fig. 2. Left lateral view. Note large translucent anterior mediastinal space. Left leaf of diaphragm visible due to gastric air bubble and it is elevated only slightly.

Fig. 3. Spot bronchogram. Stump of rudimentary left main bronchus has been filled with radiopaque oil. Branches of the right middle and right lower lobe bronchi are demonstrated. The middle lobe lies chiefly to the left of the midline.

This patient apparently represents the second type with aplasia of the lung and a rudimentary bronchus. The clinical recognition of this condition entails the coordination of physical, roentgenologic and bronchoscopic diagnostic methods. The prognostic importance of its definition is strongly emphasized by survival to adult life without serious handicap.

Since the roentgen examination plays a considerable part in the diagnosis of aplasia of the lung, a brief résumé of the changes

that may be found will be given. As would be expected, a pronounced displacement of the mediastinal structures toward the side of the defect is a constant finding. The involved hemithorax may be completely opaque so that the cardiac outline cannot be distinguished. The opposite lung herniates across the midline. The picture resembles, in these features, that produced by massive atelectasis due to occlusion of a major bronchus. As Elward[5] has pointed out, in acquired atelectasis the affected hemithorax is smaller than the normal, the interspaces are narrowed and the diaphragm elevated. In congenital absence of the lung the affected side may be decreased in size little, if any, apparently due to the remaining lung having undergone a compensatory increase in size early in life. In other cases variable amounts of aerated lung have been found on the side of the aplasia, having herniated from the opposite side. In these, areas of soft tissue density may be found at the periphery of the lung field in addition to the shadows caused by the displaced mediastinal structures. In some cases pockets of fluid have been found at autopsy. In others, masses of adipose tissue have been present. In an occasional case intestinal viscera have herniated into the thorax through a defect in the diaphragm.

While these features may suggest aplasia, the major contribution of roentgen examination results from iodized oil bronchography. In complete aplasia the trachea appears continuous with the one major bronchus present, there being no suggestion of a carina.[6] In those cases with a rudimentary bronchus, the demonstration of the bronchial bud may be possible. This may be only a rudimentary outpouching or a short, poorly developed bronchus. In addition to the proof obtained in respect to absence of a lung, bronchography of the remaining lung may show anomalous lobes and bronchial divisions.

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Vol. 57, No. 4

THE DIAGNOSIS OF ASCARIS INFESTATION BY SERIAL ROENTGEN EXAMINATION OF THE SMALL INTESTINE

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SIX instances of *Ascaris lumbricoides* infestation were diagnosed roentgenographically in an analysis of 100 small intestinal series done during the operation of this hospital in Italy and France. None of these patients was referred for this study with a previous clinical diagnosis of ascariasis. The first case was detected accidentally and recovery of the parasite confirmed the diagnosis. Thenceforth, all small intestinal studies were checked carefully for any evidence of round worms.

ROENTGEN FINDINGS

In these 6 cases the diagnosis was made on the finding of displacement of the barium by the parasite as seen in roentgenograms of the small intestine after ingestion of barium. The sharply outlined linear defect of the exact configuration of a round worm was noted in various portions of the small intestine from the upper jejunum to the lower ileum. In 1 case, only one worm was detected; in another, as many as six could be identified. The size of the worms varied from 2 to 15 cm. in length. The use of multiple hourly roentgenograms was found to be advantageous in verifying suggestive negative-shadow defects. None were detected by roentgenoscopy. The twenty-four hour check roentgenogram failed to reveal any barium residue in the intestinal tract of the parasites.

Further analysis of these intestinal surveys showed that there was no effect on the intestinal motility as reflected in the passage of the barium column. There was no noticeable change in the lumen nor in the texture of the mucosal pattern of the intestine. No irritability nor spasm was demonstrated.

Two patients who had subsequent abdominal exploration showed evidence of enlarged mesenteric .lymph nodes without change in the color or texture of the serosal surface of the small intestine. Whether or not these nodal enlargements were in any way related to the previous parasitic infestation is impossible to state from such a limited number of instances. The life cycle of the *Ascaris* and its passage through the lymphatics might imply some correlation.

There was definite symptomatic improvement in at least half of these cases after the parasites had been eliminated. The response of the other patients to therapy could not be well evaluated due to the presence of associated, more serious intra-abdominal pathology.

DISCUSSION

The fact that an incidence of 6 per cent occurred over this period of time indicates the relatively high frequency in which the diagnosis may be made by roentgenographic methods. The mention of roentgen diagnosis of this type of parasitic infestation of the small intestine is not made in textbooks on gastroenterology available for review. Garland[1] reports that ascarides may be recognized on gastrointestinal roentgen examinations as radiolucent shadows occurring especially in the jejunum. Unfortunately a complete review of the literature is not possible under the present field conditions and other similar reports may well have escaped our attention.

Due to the unavailability of the records

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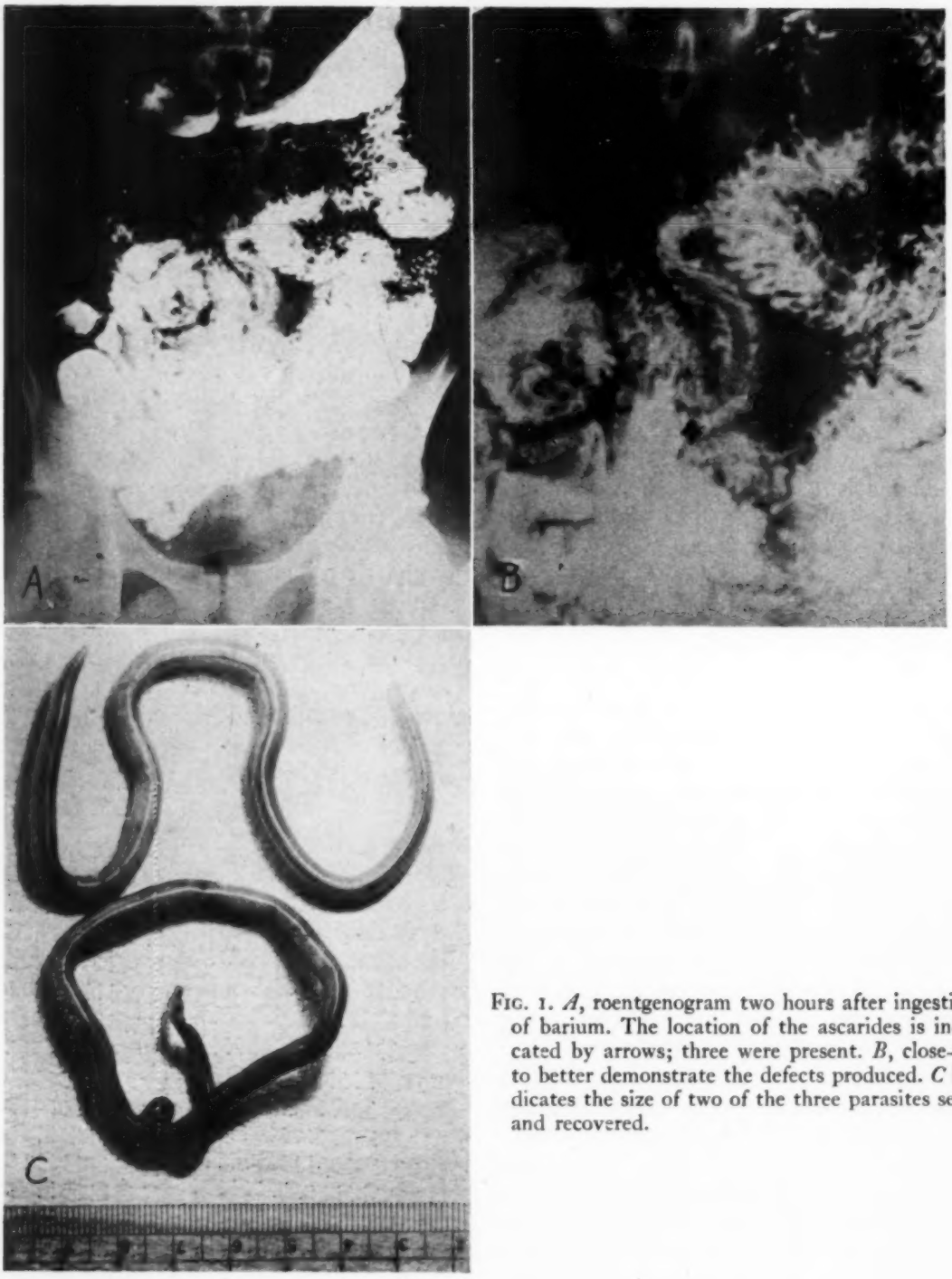

FIG. 1. *A*, roentgenogram two hours after ingestion of barium. The location of the ascarides is indicated by arrows; three were present. *B*, close-up to better demonstrate the defects produced. *C* indicates the size of two of the three parasites seen and recovered.

it is impossible to make a complete clinical analysis of the cases and only general clinical impressions are possible. This material is presented, therefore, simply as a method of diagnosis. It permits the roentgenologist to further assist the gastroenterologist in the study of a group of patients who are most apt to present a multiplicity of complaints, and in whom the present diagnostic procedures are of un-

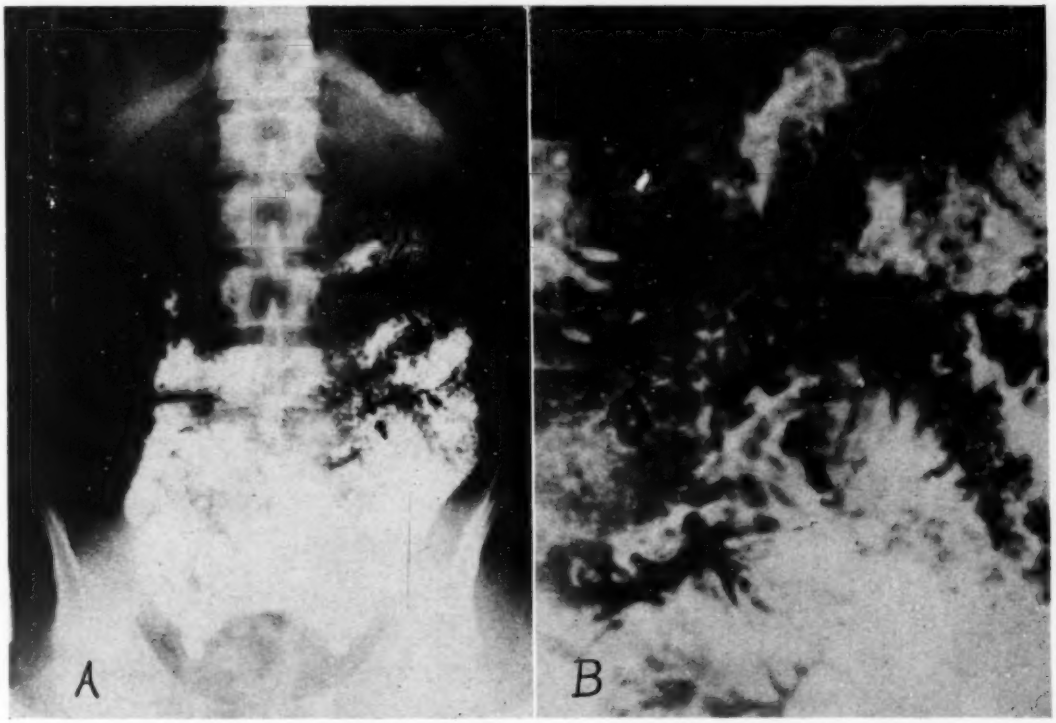

Fig. 2. *A*, the arrows indicate the position of a single parasite. *B*, close-up to demonstrate the negative linear shadow of the parasite.

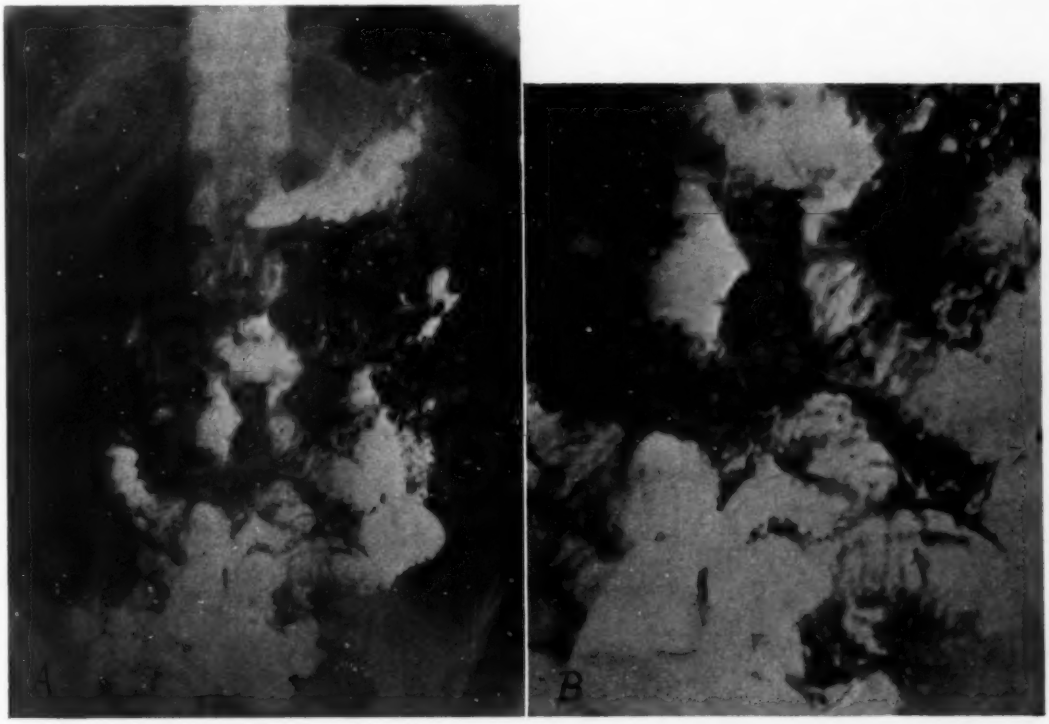

Fig. 3. *A*, two hour roentgenogram; arrows indicate the location of the two parasites. *B*, close-up to show the defect produced by the ascarides in the ileum.

usual complexity. The diagnosis of any of the pathological conditions which may be present, even though benign, provides an added aid in the approach to the treatment of this category of patients. Not all instances of *Ascaris* infestation are benign, as may be illustrated by a case that recently came to our attention in which a large round worm became lodged in the right upper lobe bronchus resulting in atelectasis, pneumonia and subsequent death.[2]

SUMMARY

1. Six cases of ascariasis diagnosed roentgenologically have been presented.

2. Diagnosis was made in the study of one hundred patients by means of serial roentgen examination of the small intestine.

3. The parasites, *Ascaris lumbricoides*, were recovered from the stool in all instances.

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EXAMINATION OF THE URINARY AND LOWER INTESTINAL TRACTS BEFORE TREATMENT OF CARCINOMA OF THE CERVIX UTERI

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IN 1939 I[2] reported 77 cases of carcinoma of the cervix uteri in which pyelographic examinations were made before treatment. In approximately 18 per cent there was definite abnormality of one or both kidneys. A recent editorial by Leucutia[1] gives an excellent summary and bibliography of articles dealing with ureteral obstruction in these patients. His conclusion is that there is insufficient evidence that ureteral obstruction is the direct or indirect result of irradiation. In the cases previously reported by me and in the present report none of the patients had received irradiation before these examinations.

I now wish to report an additional 271 cases in which intravenous pyelographic examination was made before the treatment of patients with carcinoma of the cervix uteri.

The results are summarized in the following tables.

These pyelographic examinations were made by roentgenologists at several different hospitals so that the personal equation undoubtedly made some difference in what was considered abnormal. In order to make this report as accurate as possible cases of "minimal hydronephrosis" and of "minimal hydroureter" are not considered abnormal. Also cases of slow or of diminished excretion of the drug are not reported as abnormal, only cases showing complete absence of function of one kidney being reported.

These examinations are valuable as an aid to a more definite prognosis, which is certainly unfavorable if there is evidence of ureteral obstruction. They may also help in guiding treatment, as some compressed ureters may be dilated through the cystoscope, repeatedly if necessary, to relieve the back pressure on the kidneys.

Robertson[3] has emphasized the fact that almost every pregnant woman suffers from a pathological ureterectasis and pyelectasis from the fifth month until a few weeks postpartum. Spontaneous recovery is the rule in uncomplicated cases but occasionally the hydronephrosis may be permanent. This brings up the question of a possible relationship between former pregnancies and the abnormal pyelographic findings reported in these untreated patients with carcinoma of the cervix uteri.

The following table (Table II) seems to show no connection between the number of

TABLE I

Intravenous Pyelograms—271 Cases

	Cases	Per cent
Double hydronephrosis	3	1.1
Single hydronephrosis	19	7.0
Functionless kidney	19	7.0
Hydronephrosis on one side, functionless kidney on the other	3	1.1
Abnormal pyelographic findings	44	16.2

		Abnormal Pyelographic Findings	
			Per cent
Stage I	17	0	0
Stage II	56	1	1.8
Stage III	137	20	14.6
Stage IV	40	17	42.5
Cancer recurrent in vault after panhysterectomy for carcinoma of the cervix	3	2	66.7
Cancer in cervix after supracervical hysterectomy	18	4	22.2

pregnancies and the incidence of abnormal pyelographic findings in these patients. Moreover the left kidney was involved in 26 cases, the right in 12 cases and both kidneys in 6 cases. This is of interest because Robertson found the right side involved more often than the left in the pregnant women in his series of cases.

Table II

Times Pregnant	Total Pyelographic Examinations	Abnormal Pyelographic Findings	
0	35	4	11.4%
1	45	8	17.7%
2	38	10	26.9%
3	44	6	13.6%
4 & 4+	109	16	14.7%

During the same period of observation 184 cystoscopic examinations were made before treatment of these patients.

The results are as follows (Table III):

Table III

Cystoscopic Examinations—184

Normal bladder (except an occasional slight cystitis)	149	81.0%
Mucosa shows no tumor but bladder wall is deformed by external pressure of cervical tumor or by actual invasion	32	17.4%
Tumor of bladder (histopathologic type similar to that of cervical tumor) demonstrated by biopsy	3	1.6%

In addition, examination of the rectum was made in many of these patients (137 proctoscopic examinations and 145 roentgen examinations after barium enemas). In 2 patients a small rectal polyp was removed and found to be benign on microscopic examination. In 10 patients, all with far advanced tumors, there was some deformity of the rectum or lower sigmoid, due either to pressure from the cervical tumor or to involvement of the wall of the intestine by tumor. However, in none of these 10 was the mucosa involved, hence no biopsy was performed.

SUMMARY

Intravenous pyelograms made before treatment of 271 patients showed definite abnormality of one or both kidneys in 16.2 per cent The incidence of kidney involvement suggests that this method should be used in examining all patients with carcinoma of the cervix uteri. There seems to be no connection between the number of pregnancies and the abnormal pyelographic findings reported.

Study of these patients, before treatment, by cystoscopy, barium enemas and proctoscopy showed less frequent involvement of the bladder and of the rectum than of the kidneys. These examinations should be included in any thorough pretreatment studies of these patients.

I wish to express my thanks to the members of the gynecological, radiological and urological staffs of City, St. Alexis, St. Luke's and University Hospitals for their cooperation in examining the patients discussed in this article.

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CONGENITAL MALFORMATIONS INDUCED IN RATS BY ROENTGEN RAYS

SKELETAL CHANGES IN THE OFFSPRING FOLLOWING A SINGLE IRRADIATION OF THE MOTHER*

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A RENEWED interest in the etiology of congenital malformations has become noticeable in recent years. Geneticists have engaged in studies of the developmental mechanics of abnormalities caused by mutations[1] and at the same time clinical and experimental investigators have discovered some new infectious and nutritional factors which, acting during prenatal life, may be the cause of non-hereditary modifications.[2,3,4]

Roentgen rays have been employed as a causative agent in the experimental production of malformations in two different ways. In one type of experiment genetic changes (mutations) are induced by irradiation of the sex glands of mature animals.[5,6,7] In this way the germ plasma of the irradiated animals is injured and in subsequent generations of the inbred offspring malformations have been observed. In the second type of experiment the development of embryos is disturbed in utero by irradiating the pregnant female. In this case non-hereditary modifications are induced in the em ryos which are often deformed at birth. Our study is concerned with experiments of the latter type.

Butler[8] surveyed the literature dealing with the effects of radium and roentgen rays on embryonic development. The great array of facts collected in his article is concerned chiefly with developmental disturbances by roentgen rays of eggs and embryos of lower animals but a number of experiments have been performed in mammals. Bagg[9] found that marked areas of extravasation in the subcutaneous connective tissue of developing embryos could be produced by subjecting pregnant rats either to injection of radioactive substances or to external gamma-ray radiation. Treatment of the pregnant females with gamma radiation towards the end of gestation resulted in death of one-half of the young, while the other half grew to normal size but developed eye defects and atrophy of the cerebral cortex, optic tracts, tes es and ovaries. Hanson[10] reported that female rats in the later stages of pregnancy, when given the proper doses of roentgen rays, produce litters in which one or more of the young have serious eye defects, changes in shape of the skull, and considerable retardation in growth in some instances. De Nobele and Lams[11] observed defects of the eye, hydrocephalus, fetal death and resorption in the offspring of irradiated pregnant rats. Kosaka[12] exposed white rats to roentgen rays between the eleventh and fifteenth days of gestation. He found incomplete development of some organs but no striking malformations in the offspring. Murphy and de Renyi[13] subjected 120 pregnant rats to from one to six roentgen-ray exposures of 200 to 1,200 r. Thirty-four females had litters. In 5 of these litters one or more young exhibited malformations of the extremities such as clubbing of the feet or absence of toes. Job, Leibold and Fitzmaurice[14] exposed pregnant rats to roentgen rays in order to determine the "critical periods" in mammalian development. These authors gave careful consideration to the dose administered and to the stage of development of the young. They found that a dose of 35 to 90 r when administered during the ninth, tenth and eleventh days of gestation produced gross developmental abnormalities in the offspring, such as de-

* Presented at the Forty-seventh Annual Meeting, American Roentgen Ray Society, Cincinnati, Ohio, Sept. 17–20, 1946.

fects of the eye, and of jaw and hydrocephalus. The same dose administered between the twelfth and eighteenth days of gestation did not induce abnormalities in the young. These authors believed that a dose of 95 to 200 r administered to a pregnant rat on the first to eighteenth days of

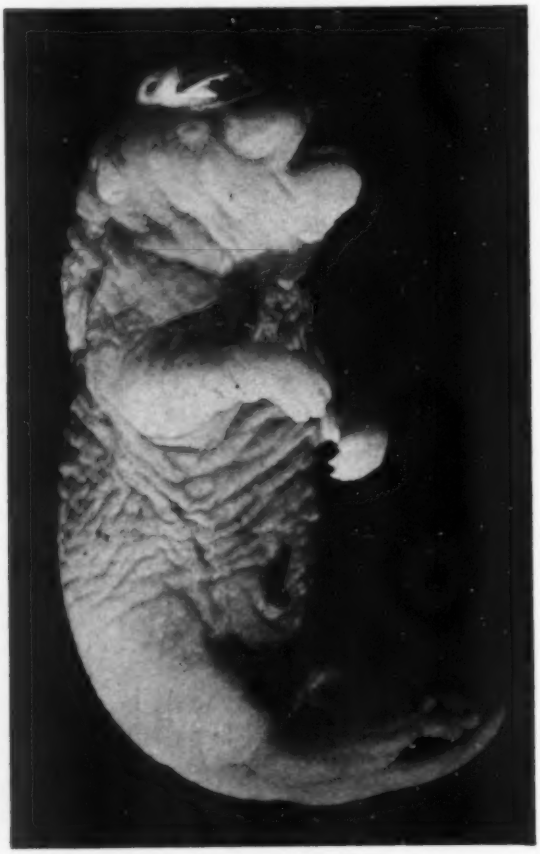

Fig. 1. Irradiation on the tenth day Note encephalocele and shortness of upper jaw.

gestation will kill all of the conceptus. Kaven[15] exposed pregnant mice to 170 to 230 r on various days of gestation. He found as the result of irradiation on the eighth day meningoceles and deformities of the brain. Treatment on the ninth to fourteenth days resulted in deformities of the tail. A high percentage of stillborn young was found after irradiation on the tenth and eleventh days and sterility of the males whose mothers had been exposed on the fifteenth and seventeenth days of prenatal life.

METHODS

The experiments to be reported in this communication were undertaken for the purpose of studying the skeletal malformations induced in the offspring of female rats exposed to a single irradiation with roentgen rays on various days of gestation. Rats of the Sprague-Dawley strain were mated and the time of conception established by the finding of sperm in the vaginal smear. The day on which sperm was found was counted as the first day of pregnancy. On the day of exposure the pregnant rat was given 1/13 to 1/10 grain of sterile veterinary nembutal (Abbott) by subcutaneous injection. Then the anesthetized animal was fastened to a board. Dorsal exposure was performed in all experiments and a lead frame was employed for the protection of the parts which were to remain unexposed. There was an opening of adjustable size in this frame, which made possible the exposure of the lumbar and sacral regions. Doses of 190 to 1,120 r were administered. The time of exposure varied from five to eight minutes. The kilovoltage approximated 100 and the filtration was 2.5 mm. of aluminum or no filtration was employed. After the roentgen treatment each rat was given 15 cc. of sterile saline solution subcutaneously. On the day after irradiation a loss of weight of 5 to 10 grams was usually noted but on subsequent days a regular gain in weight was found in the rats that continued their pregnancy. Females who resorbed their young following irradiation decreased in weight and there was blood in the vaginal smears. On the twenty-second day of pregnancy the rats were sacrificed and the young removed.

Single exposures of the mothers to roentgen rays were made on either the tenth, eleventh, twelfth, thirteenth, fourteenth, fifteenth or sixteenth day of gestation.

Only about one-fourth of the litters irradiated were resorbed and a total of 622 young were obtained from 144 mothers. Four hundred and eighty-five of the 622 young had skeletal anomalies. The young were inspected externally and many of them cleared by the Schultze-Dawson method[16] in order that skeletal changes could be studied. Serial histologic sections were made of the heads and extremities of a small number of abnormal young.

RESULTS

Exposure on the Tenth Day of Gestation. Eighteen pregnant females were irradiated

with 190 to 500 r on the tenth day of gestation. Nine of these resorbed but from the 9 that carried their litters to term a total of 44 young were obtained. The litter size varied from 1 to 10 young and the weight of the young was between 3 and 4 grams. Only 12 young had abnormalities which could be seen on external inspection. Seven had defects of the skull and the skin of the head with partial protrusion of the brain (Fig. 1); 4 had cleft palates and 2 of these also had cleft lips; 3 had short upper jaws (Fig. 1) and 2 had short lower jaws. Two young had slight abnormalities of the hands, while multiple malformations were present in 5 young. Twenty-nine young were cleared and 22 of these had defects of ossification of the skull of various degrees. Most commonly affected were the median parts of the parietal and frontal bones and the interparietal bones. With the exception of 2 cleared animals which had large defects, the retardation of ossification was not marked in the skull. Fusion of the ribs was seen in 3 specimens. The proximal parts of the ribs were separated and the fusion was present in the middle and sometimes in the distal parts. One young had absence of both ulnae and marked shortening of the femora. Other parts of the skeleton were not grossly affected.

Exposure on the Eleventh Day of Gestation. Nineteen females were irradiated with from 250 to 670 r. Four of them resorbed and 15 carried their young to term. Forty-five young were obtained. The litter size varied from 1 to 8 young. The weight of the young was from 2.7 to 5 grams. On external inspection abnormalities of the legs and feet were seen in 19 young. These lower extremities usually appeared very poorly developed. The legs and feet were reduced in size and the toes in number. The tails were short and curly in 10 young. In 4 animals there was also reduction in size of the hands and in the number of fingers. One animal had a short upper jaw. No encephaloceles were observed. Thirty-six young were cleared. The bones of the skull were slightly retarded in ossification and there was an enlarged space between the parietal and interparietal bones. The hands and ribs showed no abnormalities in the cleared specimens. The femora were short in 1 and absent in 4 animals. The fibulae were short in 3 specimens. The bone most often affected was the tibia which was shortened (Fig. 2*B*) or absent in 19 specimens.

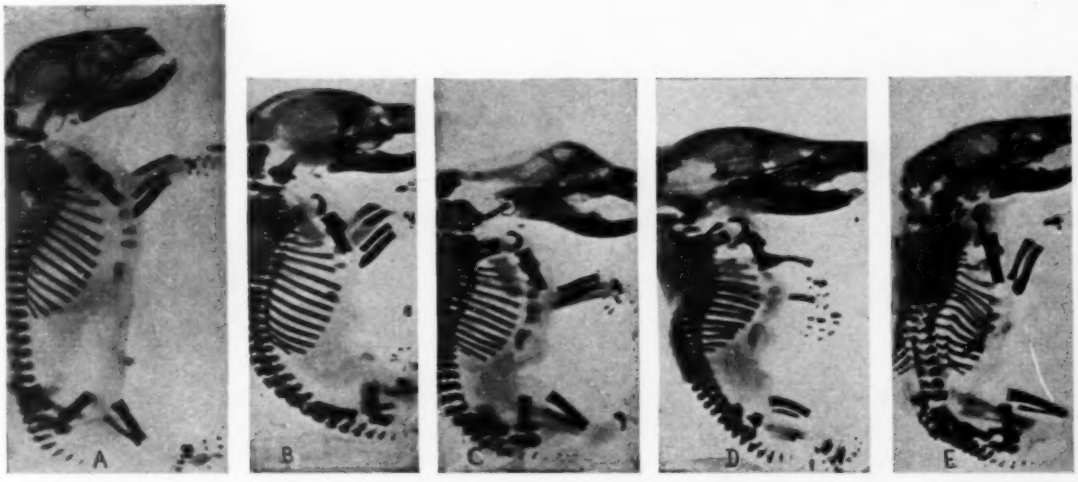

Fig. 2. Cleared specimens. (*A*) Normal control. (*B*) Irradiation on the eleventh day. Note shortness of tibia. (*C*) Irradiation on twelfth day. Note large defect of the skull. (*D*) Irradiation on the thirteenth day. Note shortness of mandible, formation of a humeroradial bone, absence of the ulna, shortness of femur and fibula. (*E*) Irradiation on the fifteenth day. Note angulation and knob formation of the posterior parts of the ribs.

Exposure on the Twelfth Day of Gestation. Twelve females were irradiated with from 190 to 670 r. One of these resorbed and 11 carried their young to term. Fifty-four young were obtained. The litter size was from 1 to 10. The weight of the young was from 3 to 5 grams. In 16 young encephaloceles were recognized by a dark discoloration of the skin the parietal region or the brain could be seen through a defect

of the skull and skin (Fig. 3*A*). Shortness of the upper and lower jaw was noticed in 9 specimens. Only 2 specimens had short extremities of the type described in the young of animals exposed on the eleventh day. Shortness or absence of the tail was seen in 33 young. One young had a cleft palate. Forty-three young were cleared and 31 of them were found to have large defects of the skull in the parietal-interparietal region (Fig. 2*C*). Two specimens had defective femora, tibiae, fibulae and feet. Serial histological sections were made of 1 400 r always resulted in abnormal young. One hundred and fifty-three young could be recognized as abnormal by external inspection. Nineteen young had encephaloceles, 40 shortness of the lower jaw and 40 cleft palates. Frequently the arms appeared short and the hands abducted. Syndactylism was noted in 140 hands. Club feet and syndactylism of the toes were also often seen. Thirteen young had polydactylism (6 to 7 fingers or toes). The tail was short in 95 specimens. Of the 128 animals cleared, 78 had defects of the skull, and 32 short mandibles.

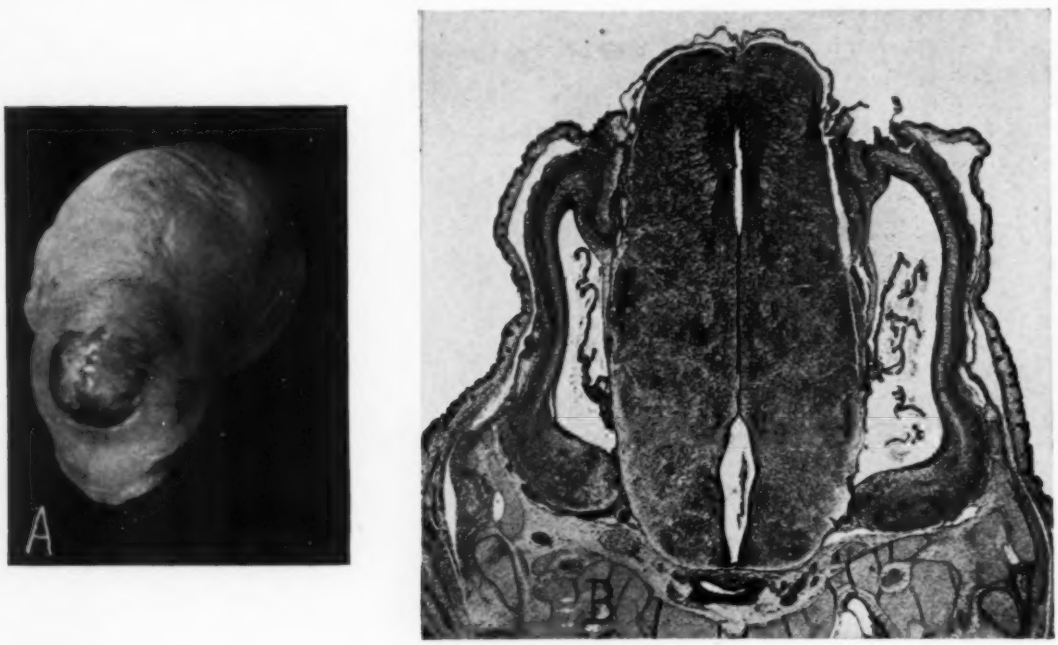

Fig. 3. Irradiation on the twelfth day. (*A*) Note encephalocele in the parietal region. (*B*) Section through an encephalocele.

young with encephalocele. One of these sections is reproduced in Figure 3*B* to show the contents of the protruding area and its relationship to the cranium. The deformity of the brain stem, atrophy of the cerebral cortex and enlargement of the lateral ventricles can be seen.

Exposure on the Thirteenth Day of Gestation. Sixty-seven females were irradiated with from 190 to 900 r. Nineteen of these resorbed and 48 carried their young to term. Two hundred and forty-nine young were obtained. One hundred and ninety-three of the 249 young were abnormal. All of the 56 normal young were the offspring of mothers who had been exposed to doses under 400 r, while exposure to more than The ramus and the corpus of the mandible were equally reduced in size. In 32 specimens the humerus and the radius showed osseous fusion (Fig. 2*D* and 6*A'*). The radius was short in 10, and the ulna short or absent in 44 young. The femora were short or absent in 25, the tibiae in 28 and the fibulae in 32 specimens (Fig. 2*D* and 6*A'*). The ribs were reduced in size in 20 young.

Histologic sections of some of the abnormal bones were made. Sections of an arm with osseous ankylosis of the humerus and the radius showed absence of the distal epiphysis of the humerus and of the proximal epiphysis of the radius. The osseous trabeculae of the two bones

were connected without demarcation. Figure 4*A* represents the section of a specimen with cartilaginous connection of the radius and humerus. The distal cartilage of the humerus and the proximal cartilage of the radius had normal structure but the humeroradial joint was not developed. Figure 4*B* illustrates the abnormal tibia and fibula of one specimen. The proximal ends of the tibia and the fibula are fused. In the central parts of the tibia the development of a center of ossification is seen. It consists of a small area of swollen cartilage cells and the rest of the tibia is made up of undifferentiated cartilage cells. In the cartilaginous fibula no signs of ossification can be recognized. Similar retardation of ossification is seen in the small bones of the hands and feet and many of these structures remain united since joints have not yet developed between them.

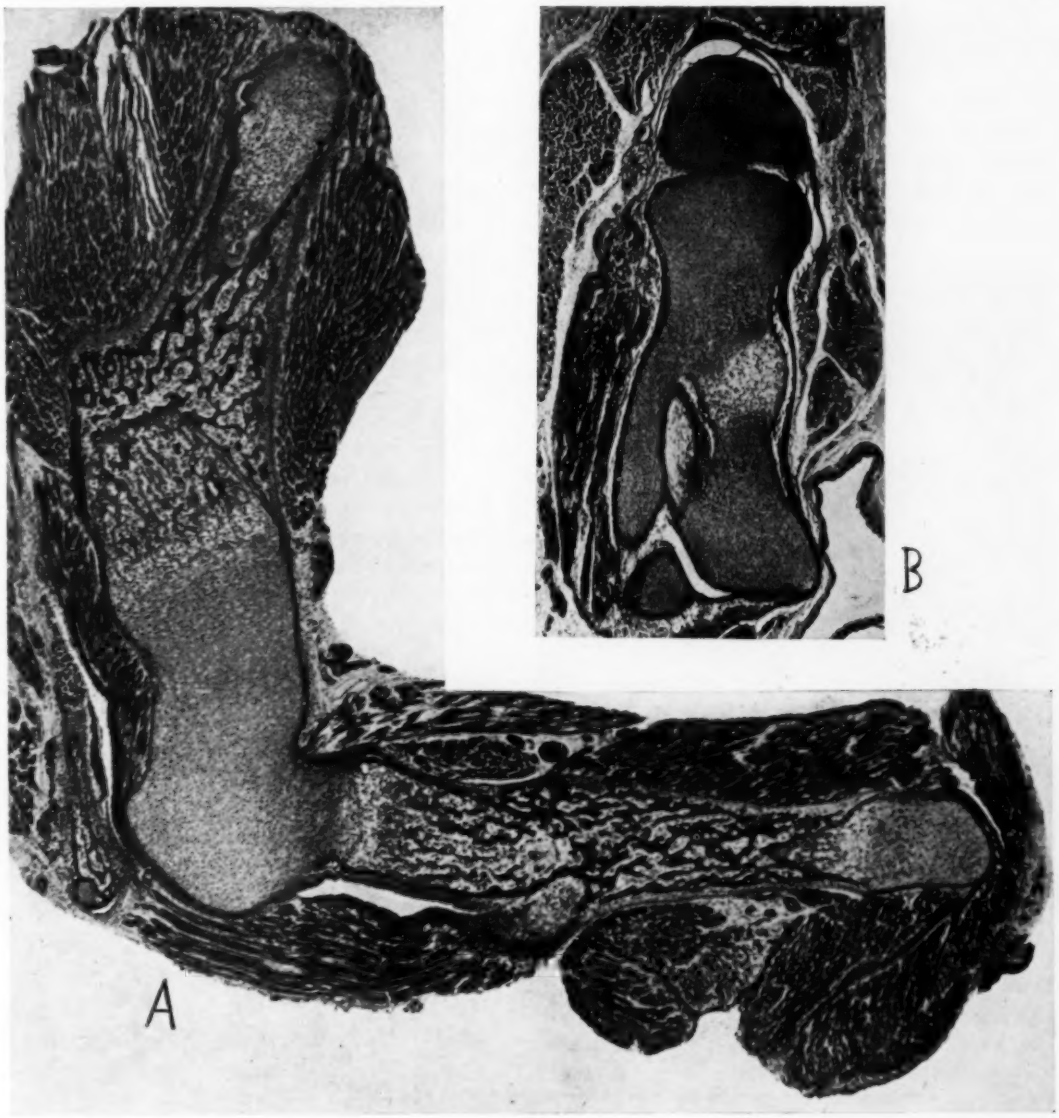

Fig. 4. Irradiation on the thirteenth day. (*A*) Humeroradial bone. There is a continuous cartilaginous connection between the humerus and the radius. (*B*) The fibula and the tibia have remained essentially cartilaginous. Since the proximal tibiofibular joint as not formed, the two bones appear fused.

Exposure on the Fourteenth Day of Gestation.

Eight females were irradiated with from 190 to 950 r. They carried their litters to term and 50 young were obtained. The litter size varied from 1 to 11 young. The 3 mothers of 26 young were exposed to relatively small doses of from 190 to 250 r. Their offspring appeared externally normal with the exception of underdevelopment of the hands and feet and of reduction of the number of toes. One young had a cleft palate. Ten young were cleared and showed reduction of the small bones of the hands and feet, 3 had defects of the skull and 1 had short fibulae. The 5 mothers of 24 young were exposed

Fig. 5. Irradiation on the fifteenth day. Cleft palate.

to much larger doses of 890 to 950 r. Their young showed severe malformations. Their bodies were small and pudgy. Seven had short mandibles and 22 cleft palates. All had deformities of the extremities which were short and underdeveloped. There was syndactylism, clubbing of feet and absence of toes. Fourteen specimens were cleared and 7 of these had reduced mandibles, while the ribs of 8 were short or absent. Three had short ulnae, 3 short tibiae and 10 short or absent fibulae. In 1 young the radius and humerus were fused.

Exposure on the Fifteenth Day of Gestation. Eleven females were irradiated with from 250 to 300 r. Ten of these carried their litters to term and 69 young were obtained. The heads of the young appeared externally normal but cleft palate was found in 20 specimens (Fig. 5). The changes observed in the ribs were characteristic for irradiation of the fifteenth day. A peculiar angulation was seen near the vertebral column (Fig. 2*E*) and a bony knob above the angle. This abnormality of the ribs occurred in 60 of 63 cleared specimens. The bones of the extremities were normal with the exception of those of the fingers and toes which were reduced in number. The tails were short and curly in 49 specimens. One female was irradiated with 1,120 r and 12 young were obtained. These young appeared externally very abnormal since they had short upper and lower jaws. All had cleft palates. The hands and feet were small and underdeveloped. The tails were short and curly. The cleared specimens had abnormalities of the ribs which resembled those obtained by the small dosage described above but in addition they were very short. The long bones of the extremities were essentially normal.

Exposure on the Sixteenth Day of Gestation. Seven females were irradiated with 300 r and 5 of these carried their 35 young to term while 2 resorbed. The young appeared externally normal with the exception of a slight reduction of the fingers and toes. They did not have cleft palates. After clearing, angulation of the ribs was seen in 9 specimens which were otherwise normal. One female that was exposed to 1,120 r had 10 young. Of these, 3 had short upper and lower jaws, 1 cleft palate and 5 angulated ribs.

COMMENT

The experiments described in the foregoing pages show that congenital malformations can be induced in the offspring of rats with great regularity, if the mothers are exposed to roentgen rays during pregnancy. If the experimental conditions employed by us are observed, a great variety of malformations occurs. Of these only the skeletal defects are described in this paper. A single exposure to roentgen rays was given in all cases. The period of irradiation varied from the tenth through the sixteenth day of gestation. The variation of skeletal abnormalities may at first appear confusing. However, certain patterns can be discerned in this diversity and correlated with some known experimental factors.

The day of irradiation is of great impor-

tance. This point had been stressed by Job, Leibold and Fitzmaurice[14] who employed relatively small doses on the ninth, tenth and eleventh days of gestation. We succeeded in inducing abnormalities on the following five days of gestation. This was achieved by higher doses than those employed by Job, *et al.* who considered exposures to more than 200 r as lethal to the embryos. With the higher doses malformations of the brain, of the eye and of the upper and lower jaws, resembling those induced by Job, *et al.*, could be induced by exposure after the eleventh day. This indicates that the critical periods are not limited sharply to certain days. The dose applied also has a decisive influence upon the type and the severity of the malformations. This is best illustrated by our findings with irradiation on the fourteenth day. The offspring of mothers exposed on that day to 190 to 250 r appeared externally normal with the exception of slight abnormalities of the fingers and toes. There was only one cleft palate in the 26 young obtained in this way. The offspring of the mothers exposed to 890 to 950 r appeared severely deformed on external inspection. They were small and pudgy, not only their toes but their entire extremities were underdeveloped and 22 of the 24 young had cleft palate.

Sometimes there were variations of the deformities in the different members of the same litter. These variations sometimes represented only gradual differences, but in certain litters normal and abnormal young were found together. This fact, which was also observed by Job and coworkers, was explained by these investigators on the assumption that the embryos were in different stages of development at the time of treatment. We observed repeatedly that the young found in the upper parts of the uterine horns were more abnormal than those found low and near the exit of the birth canal. It is possible that this difference is due to a lesser degree of maturity and to a higher susceptibility of the embryos located higher in the uterine horns. Such different degrees of maturity of the embryos would also explain the overlapping of patterns obtained by irradiation on subsequent days.

While thus the pattern of abnormalities was not determined entirely by the day of gestation on which the irradiation took place, it should be pointed out that some defects were not produced by exposure on certain days. Thus defects of the skull were seen after irradiation on the tenth, twelfth, thirteenth and (in few instances) on the fourteenth days. On the eleventh, the fifteenth and sixteenth days no skull defects were induced. The characteristic angulation within the osseous parts of the ribs was obtained in the young of animals exposed on the fifteenth and sixteenth days but not in those exposed on the previous days. The formation of a humeroradius seems characteristic for the thirteenth day of irradiation. Only one young irradiated on the fourteenth day but none of the young exposed on other days had a similar defect. Cleft palate was found after irradiation on the tenth, twelfth, thirteenth, fourteenth, fifteenth and sixteenth days; but the incidence was particularly high in the offspring of animals irradiated on the fifteenth day, when low and high doses were effective. There are parts which are especially vulnerable, such as the fingers, toes and tails, and they are affected by irradiation from the tenth to the sixteenth days. The vertebral column—with the exception of its caudal part—was normal in all the specimens examined. Such differential susceptibility is not limited to modification of embryos by roentgen rays. Similar results have been observed in the young of mothers bred on a diet deficient in riboflavin.[17] In that pattern the skeletal structures near the mid-dorsal region are normal, while the more ventrodistally situated ones are more often deformed.

Exposure on the thirteenth day was practiced on a rather large scale, since previous nutritional experiments[18,19] had indicated that at this period a critical state exists in rat embryos in which certain mal-

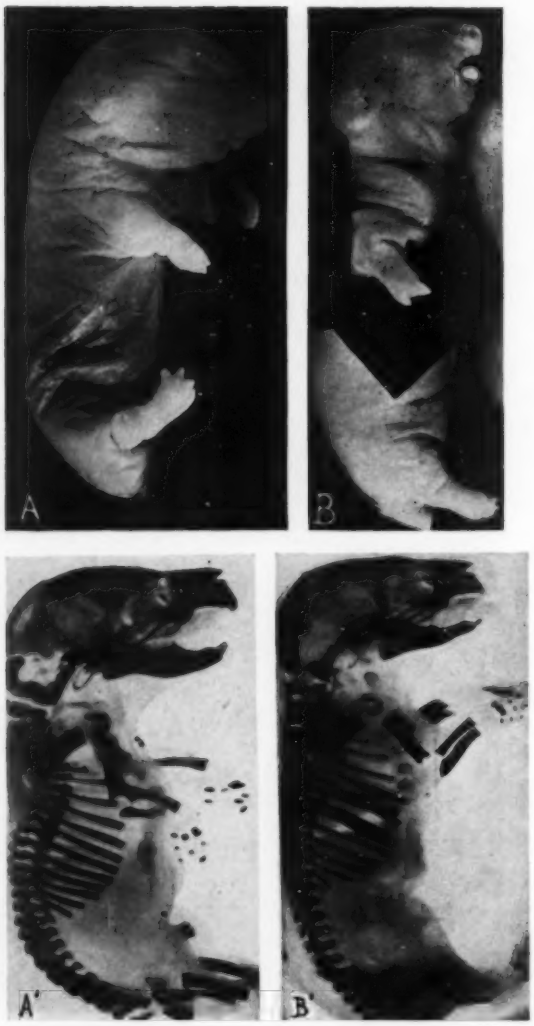

Fig. 6. (*A* and *A'*) Irradiation on the thirteenth day. (*B* and *B'*) Young of mother fed on riboflavin deficient diet. Note external resemblance of (*A*) and (*B*) and difference of the cleared specimens (*A'*) and (*B'*). In (*A'*) a humeroradial bone is seen and the ulna is shortened. The ribs are normal. In the leg the fibula is underdeveloped and the femur shortened. In (*B'*) there is fusion of two pairs of ribs. In the leg the tibia is absent, the fibula of approximately normal length and the femur normal. In both specimens the mandible is shortened, but in (*B'*) the corpus mandibulae is essentially underdeveloped, while in (*A'*) the reduction in size is due to shortening of both ramus and corpus.

formations of the skeleton are determined. It was shown that on a diet deficient in riboflavin (diet 1), female rats gave birth to young one-third of which had congenital malformations. The abnormal young could be recognized externally by the shortness of mandible, protrusion of the tongue and in many cases by shortness of the arms and legs, syndactylism and club feet. After clearing, shortness or absence of the corpus mandibulae, radius, ulna, fibula, tibia, and of the small bones of the hands and feet, and fusion of the ribs and centers of ossification of the sternum were seen. These malformations could be prevented by the addition of riboflavin or liver to the deficient diet 1 as late as the thirteenth day of gestation, while after that date liver was not preventive. From this and from embryologic and histologic studies[20] it was concluded that the malformations were determined between the thirteenth and fourteenth days of gestation. It seemed of interest to study the effects of roentgen rays in this critical period and to compare them with those obtained by nutritional deficiency.

The rat in Figure 6*A* is the offspring of a mother fed an adequate diet but irradiated with roentgen rays on the thirteenth day of gestation. In Figure 6*B* an abnormal newborn rat is shown whose mother was on a diet deficient in riboflavin. An external comparison of the two specimens reveals definite resemblance. The shortness of the mandible, the syndactylism of the hands, the shortness of the legs and the supination of the feet are so similar in these two specimens that one might think that the abnormalities are identical. However, a comparison of two cleared specimens demonstrates definite differences of the two patterns. In the pattern of abnormalities produced by exposure to roentgen rays on the thirteenth day (Fig. 6*A'*), both the ramus and the corpus mandibulae are reduced in size and the ulna and the fibula are more shortened than the radius and the tibia. There is also a humeroradial bone which was never observed in several hundred abnormal specimens of the pattern of diet 1, induced by maternal nutritional deficiency. In that pattern (Fig. 6*B'*), the shortening of the mandible is due to a reduction in size of the corpus mandibulae, while the ramus is of normal size. The radius and the tibia are

usually more shortened than the ulna and the fibula. Thus the two patterns may appear rather similar on external inspection, but there are definite differences in the skeletal defects as seen by comparison of the cleared specimens.

SUMMARY

A method is described which permits the production of congenital malformations in the offspring of female rats by exposing them to roentgen rays on certain days of pregnancy. Of 622 young, obtained from 144 mothers, 485 had skeletal malformations. Defects of the bones of the skull, cleft palate, shortness of the mandible and malformations of the ribs and of the bones of the arms and legs were observed. Certain patterns of deformities could be established which depended upon the day of irradiation and upon the dose of roentgen rays administered. Many of the young obtained by irradiation of the mother on the thirteenth day of gestation have external resemblance with the young of mothers reared and bred on a diet deficient in riboflavin, but after clearing the malformations induced by irradiation and those produced by nutritional deficiency can be easily distinguished.

We wish to thank Dr. Harold G. Reineke and his staff in the Roentgen Department of the Children's Hospital, Cincinnati, Ohio, who made this study possible by their advice and technical assistance.

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THE CORRELATION OF TISSUE DOSE AND CLINICAL RESPONSE IN IRRADIATION OF BONE TUMORS AND OF NORMAL BONE

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LITTLE uniformity of opinion has been expressed in published reports on the effectiveness of radiation therapy in the treatment of bone tumors, or on the amount of radiation which will cause serious damage to normal bone. Much of this confusion is due to the fact that air doses rather than tumor doses have been reported. Accordingly it seemed desirable to correlate the tissue doses with the clinical course in a series of patients with bone neoplasms in order to obtain an approximately quantitative estimate of the amount of radiation required to inactivate the tumors and to abolish the regenerative capacity of normal bone.

METHODS

One patient was treated with the radium element pack and 3 were treated wholly or in part with 1,000 kv. roentgen rays. Calculations of tissue doses for these patients were made by means of tables prepared in this Hospital for these installations. For the remainder of the patients the roentgen factors were either 200 kv. with 0.5 mm. copper filter or 250 kv. with 1.5 mm. copper filter. Target-skin distances varied from 35 to 70 cm., usually 50 cm. Tissue dose calculations for treatments given under these conditions were made by means of the tables in "Physical Foundations of Radiology" by Glasser, Quimby, Taylor and Weatherwax (Hoeber, 1945).

The data in all the tables used were obtained by the use of various types of phantoms equivalent to soft tissues in absorption characteristics. It is known[1] that the absorption of penetrating radiation by bone is higher than that by soft tissues, but no correction for this has been made in the present work, as the methods of calculation are not well standardized.

In most cases radiation was administered in doses of about 250 roentgens to one or two fields daily or on alternate days, the total course being completed in two to four weeks. When more than one course of treatment was given to the same area over a period of months or years, this fact is noted in the text.

In the majority of cases the depth below the skin of the tumor or bone under consideration was obtained by measurement of appropriate roentgenograms. This introduces a slight error due to parallax, but, as the roentgenograms are usually made at a distance of 100 cm., the error is only a few millimeters. Sometimes direct measurements of the patients were made, but this is often unsatisfactory. In a few cases when neither the patient nor suitable roentgenograms were available it was necessary to estimate depths by measurements of another individual of the same size and build. This introduced a considerable error, but it is felt that the error in tissue dose calculations due to faulty depth determinations does not usually exceed 10 to 15 per cent.

Calculations were usually made of the dose at the center of the tumor. In cases where satisfactory cross-firing could not be obtained, so that some portions of the tumor received less radiation than others, calculations were made at the point in the tumor which received the smallest dose.

The effect of irradiation was evaluated in different ways according to the disease under consideration, and will be considered separately for each diagnosis.

OSTEOGENIC SARCOMA

Thirty-nine cases of osteogenic sarcoma were available for study. In all except one the diagnosis was established histopathologically either by biopsy or by radical

surgery. The effects of irradiation were evaluated on the basis of clinical improvement, reduction in serum or tissue alkaline phosphatase, and histopathological evidence of tissue damage.

Clinical effects consisted in relief of pain, reduction in swelling, and improvement in general physical status. In patients who underwent amputation immediately after the completion of irradiation, there was usually not sufficient time to evaluate the clinical effect, but in a few very prompt relief was obtained, and could be taken into consideration.

In a previous publication Woodard and Higinbotham[2] showed that, when a phosphatase-producing osteogenic sarcoma is irradiated sufficiently heavily, the production of phosphatase diminishes greatly at about the same time that the growth of the tumor stops. In the present work, when the serum alkaline phosphatase was elevated before treatment, a fall during treatment, or the presence of low phosphatase readings in the tumor tissue obtained after treatment, was considered as an indication that the tumor had been inactivated at least temporarily by the therapy. Some types of osteogenic sarcoma do not produce significant amounts of alkaline phosphatase. Hence, when the serum alkaline phosphatase was not elevated before treatment, the phosphatase readings could not be used as an index of the rate of tumor growth, and are not considered in evaluating the effect of the treatment.

When the patient submitted to amputation within a few weeks after the end of radiation treatment, the pathologist's report indicated the extent of damage to the tumor.* When, as happened in 3 patients, there was primary clinical relief followed after several months by relapse and amputation, the histopathological findings were not considered, as most of the tumor tissue obtained at such late operations had been formed after the effect of irradiation had disappeared.

Of the 39 patients under consideration, 8 received tumor doses of 850 to 2,550 r. One of these patients was treated with the radium element pack. Transitory and incomplete clinical relief was observed in 2 cases and some diminution of phosphatase activity in 4 cases. No histopathological evidence of tissue damage was demonstrable in the 5 specimens available for examination. It appears that doses as small as this are of little use in the treatment of osteogenic sarcoma.

Seven patients received tumor doses of 3,000 to 3,920 r. Of these, one was treated at 1,000 kv. and one received 200 to 300 equivalent roentgens from radioactive phosphorus stored by the tumor in addition to a tumor dose of 3,700 r from external irradiation at 250 kv. There was some evidence of clinical control of disease in all cases, but the 3 patients who did not submit to amputation immediately after the completion of radiation therapy showed evidence of relapse in two to four months. There was definite reduction in phosphatase in 4 patients, no effect in 1, and in 2 patients phosphatase readings were not available. In 1 case tumor tissue was not available for microscopic examination after irradiation, in 3 no radiation changes were discernible, and in 3 there was considerable necrosis but the tumors were still viable. In no case was there evidence that tumor doses between 3,000 and 4,000 r would cause more than temporary palliation.

Seventeen patients received tumor doses of 4,000 to 5,850 r. In the patient who received 5,850 r the treatment was given in two courses six months apart, and in a patient who received 4,040 r the treatment was given in three courses. In 5 patients amputation was performed too soon after the completion of irradiation for the clinical effects of treatment to become apparent. In 11 of the remaining 12 patients there was moderate to marked clinical relief, but this was followed by relapse in an average period of eight months, with a range of one month to two years.

In 9 of the 12 cases in which phosphatase readings were available there was evidence of reduction in the phosphatase activity of

* We are indebted to Dr. F. W. Stewart for reviewing the slides of many of these cases.

the tumors. In 8 of the 12 cases in which microscopic examination of the tumor tissue could be made after treatment there was evidence of varying degrees of damage, but in none was the tumor completely devitalized. From these results it seems that tumor doses of 4,000 to 6,000 r will control most cases of osteogenic sarcoma for a number of months, but will not inactivate the tumor permanently.

Seven patients received tumor doses of 6,450 to 9,100 r. In the patient who received 9,100 r the treatment was given at 1,000 kv. in two courses two months apart. There was marked clinical relief in all cases, and nearly or quite complete abolition of phosphatase activity in all the 5 cases for which data were available. Five specimens of tumor tissue were examined microscopically after irradiation. In all there was evidence of severe damage, and in 2 which received 8,000 r and 9,000 r the tumor appeared not to be viable. It thus appears that tissue doses of 8,000 to 9,000 r may sometimes be lethal to osteogenic sarcoma. It must be remembered, however, that, since these tumors are usually deep-seated, the coincident damage to adjacent normal bones and soft parts is likely to be so severe as to give little hope of preserving a useful limb.

The data presented above may be summarized as follows:

Tumor Dose	Clinical Effect
Less than 3,000 r	Little or none
3,000 to 4,000 r	Transitory control in some cases
4,000 to 6,000 r	Control for several months in most cases
6,000 to 9,000 r	Marked clinical control in all cases; occasional complete inactivation

We feel that, unless an osteogenic sarcoma is so situated that a dose of at least 4,000 r can be delivered, there is little use in irradiating it at all. Tumor doses of 4,000 r or more will usually give definite palliation for a number of months, and may be useful in patients who refuse surgery or in whom surgery is inadvisable because of the location of the tumor, the general physical condition, or the presence of distant metastases. Radiation therapy cannot be relied upon to effect a permanent cure of this disease.

While most primary osteogenic sarcomas appear to be so radioresistant that irradiation will afford only temporary palliation, we have some evidence that the type of osteogenic sarcoma which sometimes arises secondarily in areas of Paget's disease or polyostotic fibrous dysplasia may be moderately radiosensitive. Thus, one osteogenic sarcoma of the scapula arising on polyostotic fibrous dysplasia was controlled for eleven years after a tumor dose of 2,100 r, but ultimately recurred. In a similar tumor in the femur which received a tumor dose of 3,100 r, there was no local recurrence for four years, although the patient then died of generalized metastases. A third patient who had an osteogenic sarcoma arising in an area of Paget's disease in the humerus died of heart disease four years after the administration of a tumor dose of 3,400 r without evidence of renewed activity of the tumor. Diagnoses were proved histopathologically in all 3 cases. Further data on the effects of radiation treatment of these rather rare secondary osteogenic sarcomas would be desirable, as the results in these 3 cases suggest that it may be of considerable benefit.

RETICULUM CELL SARCOMA OF BONE

We have only 5 cases of reticulum cell sarcoma of bone treated primarily by radiation therapy. Diagnoses were established histopathologically in all cases, but in 2 the structure was atypical. Tumor doses ranged from 2,200 to 3,700 r. All patients experienced prompt relief of symptoms. One, who received 2,500 r, showed evidence of renewed activity of the disease three months after treatment. The others have remained free of local recurrence for from one to eight years, although one developed metastases fifteen months after the end of treatment.

The patient who had the smallest dose of radiation (2,200 r) was also treated intensively with Coley's toxins. From the results in this small series it appears that reticulum cell sarcoma of bone is sufficiently radiosensitive so that there is hope that it may be controlled permanently by doses of radiation which will not cause serious damage to adjacent normal bone.

ENDOTHELIOMA OF BONE

It is difficult to judge the ultimate effects of radiation therapy of endothelioma of bone because the disease is so malignant that most patients die of disseminated metastases before the final effect of treatment of the primary lesion is apparent. The 14 cases presented here are the only ones in our files in whom the diagnosis of endothelioma of bone was proved histopathologically, who survived for one year or more after radiation therapy of the primary tumor. Three of these patients underwent surgical removal of their tumors one week to two months after roentgen therapy, and in these the effect of irradiation was evaluated by microscopic examination of the tumor tissue. In the remainder the effect of treatment was judged by clinical and roentgenographic evidence of tumor activity. The effect on the primary tumor is the only one considered here, although many of the patients were given additional therapy to various metastatic areas.

The results in these patients suggest that endothelioma of bone is quite variable in its response to irradiation and that the widely held belief that it is highly radiosensitive is based on the promptness with which pain is relieved, rather than on evidence of long term control of the disease. All of the patients in our series experienced remission of symptoms and regression of the tumor during or immediately after radiation therapy.

One patient received a tumor dose of only 1,380 r. The tumor was controlled for fourteen months and then recurred.

Ten patients received tumor doses of 3,185 to 5,450 r. In 3 of them the tumor was removed surgically one to eight weeks after treatment; one tumor was fully active, while in 2 no viable neoplastic cells could be found. One patient died of disseminated disease one year after treatment, and at autopsy viable tumor was found in the irradiated area. Among the 6 patients of this group from whom tissue was not obtained for microscopic examination after irradiation, 2 showed clinical evidence of recurrent tumor activity after eleven and seventeen months; 4 showed no evidence of recurrence after thirteen, eighteen, twenty-three and thirty months. Thus, despite the early favorable response, tissue doses of 3,000 to 5,000 r will apparently control the growth of only about half of these tumors for extended periods.

Three patients received tumor doses of 6,025, 6,300 and 7,790 r, treatment of the last being administered in three courses over a period of seventeen months. One of the patients showed no evidence of local recurrence fifteen months after treatment, although she had generalized metastases. The other 2 are living without evidence of disease eleven years after treatment. In both of these last the diagnosis of Ewing's endothelioma of bone was accepted by the Bone Sarcoma Registry of the American College of Surgeons. It seems that, in a few favorable cases, doses in excess of 6,000 r may sterilize this tumor permanently.

GIANT CELL TUMOR OF BONE

Our series of giant cell tumors of bone treated solely by irradiation embraces only 11 cases, because, on the Bone Service of Memorial Hospital, surgery is the treatment of choice for this disease. Diagnoses were made by clinical and roentgenographic findings in 4 cases, and by aspiration biopsy in the remainder. Six of the patients received their treatment in two or three successive courses over periods of months or years. This plan of treatment was in favor in the past, but we now feel that in giant cell tumor, as in other types of neoplasms, it is more satisfactory to attempt a radical cure by means of a single adequate course

of irradiation administered in two or three weeks.

Three patients received tumor doses of 925 to 1,200 r, with control of the tumor and good bone regeneration for from one to four years. After four years the tumor which received 1,200 r recurred and was given an additional tumor dose of 1,120 r. There has been no further evidence of activity in the succeeding five years. The others have been observed for only one year and may still show late recurrence. It is probably not safe to rely on doses as small as these for the permanent cure of giant cell tumor.

Five patients received tumor doses of 1,950 to 3,800 r in one, two, or three courses, and have shown no recurrence of the tumor and good functional results for from one to fourteen years. In the 2 who received tumor doses of 3,600 r and 3,800 r there is some impairment of mineralization of the irradiated bones and actual or impending ulceration of the skin fourteen and three years after treatment respectively.

Three patients received tumor doses of 5,600 to 7,800 r in two or three courses over periods of five to twenty-one months. There was no recurrence of the tumor for from three to six years in any case, but late radiation changes in skin and bone made it necessary to perform amputations in 2 cases and to do numerous plastic operations in the third. The effect of large doses of radiation on bone regeneration is discussed more fully below, but it is noteworthy that the reason for administering further radiation to 2 of these patients was failure in recalcification after initial tumor doses of about 2,700 r. This was erroneously interpreted as indicating residual activity of the tumor, but subsequent study strongly suggests that the effect was really an impairment of the regenerative capacity of the adjacent normal bone.

In this small series there were no recurrences in tumors which received doses of 3,000 r or more, but in several cases there were undesirable late radiation changes. It therefore appears that tissue doses greater than 3,000 r are unnecessary and undesirable in the treatment of giant cell tumors. The minimum effective dose cannot be determined from this series, but it seems likely that it lies between 1,500 and 2,500 r.

BONE REGENERATION

While the metabolism of bone is slower than that of soft tissues, bone, like all living material, is continually breaking down and regenerating. Normally the two processes proceed at the same rate. If the regenerative process is slowed for any reason there is no immediate conspicuous change, but sooner or later demineralization and alterations in texture become evident. In normal bone a fracture or other injury is followed by a great increase in the rate of regeneration. In bone whose regenerative capacity is impaired this increase after injury does not take place, and healing is slow and incomplete.

In planning the radiation therapy of bone tumors it must not be forgotten that the aim is not only to control the disease but also to permit the regeneration of useful bony structure in the affected part. Irradiation reduces not only the rate of growth of the tumor but also the rate of regeneration of the adjacent normal bone. It sometimes appears that healing of bone is stimulated by irradiation. In reality healing is permitted in an irradiated area because the progression of the disease is inhibited more than is the process of repair. If the nature of the disease is such that it is less susceptible to injury by irradiation than normal bone, then, although it may be possible to cure the disease, it will not be possible to restore the integrity of the part. For this reason it is important to obtain at least an approximate measure of the amount of radiation which can be tolerated by normal bone.

We have studied the relation of radiation dosage to bone regeneration and bone growth in 22 patients. The treatment was given for a variety of lesions, including

giant cell tumor, 9 cases; endothelioma of bone, 6 cases; carcinoma metastatic to bone, 2 cases; overlying soft part tumor, 2 cases; undiagnosed osteolytic lesions, 2 cases; reticulum cell sarcoma of bone, 1 case. In all cases the lesions were controlled for periods long enough so that the behavior of the adjacent uninvolved bone could be studied. The times of observation ranged from one to fourteen years, with an average of five years. The regenerative capacity of the bone was estimated by observing the degree of restoration of integrity and structure, and the extent of mineralization. In 11 patients the treatment was given in a single course; in the remainder it was given in two or three courses. We realize that the effect of successive courses of irradiation delivered at intervals of several months, while cumulative, is not strictly additive, but in this series the methods of treatment were too diverse for us to study the differences in detail.

Three adults and one child received bone doses of 1,710 to 3,000 r. There was no evidence of damage to the irradiated bones, and mineralization was good one to eight years later.

Eight adults and one child received bone doses of 3,470 to 4,290 r. In one adult and the child there was no evidence that bone regeneration had been impaired. In the remaining 7 adults there were varying degrees of abnormality of texture and loss of density in bones which had been normal prior to irradiation. These changes disappeared in one to three years in 2 patients, but persisted for five to fourteen years in the remaining 5 patients. Useful function was preserved in all cases. It thus appears that radiation doses of the order of 3,500 to 4,500 r will usually decrease the capacity of normal bone to repair the damage of ordinary use so that some degree of demineralization results. The damage may or may not be permanent, but it is likely not to be disabling unless a late fracture is sustained.

Three adults and 6 children received bone doses of 5,420 to 7,790 r. In all the adults the regenerative capacity of the bone was completely lost, and in 2 in whom reparative surgery was done later the specimens removed at operation contained no viable bone cells. In 2 of the children similar disastrous effects of over-irradiation were observed. In the remaining 4 children, while the growth of the irradiated bones was retarded and their texture abnormal, there was preservation of useful function for periods up to nine years. Thus, doses between 5,000 and 8,000 r are likely to cause severe damage to, or death of, adult bone. Similar doses will also cause permanent injury to the growing bones of children, but sufficient regenerative capacity may remain so that function will be preserved.

This observation that young bone appears to be more resistant than adult bone to devitalization is unexpected, since it is well known that irradiation of the epiphyseal regions will inhibit bone growth.[3,4,5] Doses as small as 600 r have been reported to cause a temporary reduction in the growth rate of the bones of young animals, and somewhat larger doses will stop growth permanently. Apparently the capacity of young bone to grow is more readily injured by irradiation than is its capacity to repair the wear and tear of normal use.

While in our series we did not find evidence of damage in bones that had received less than 3,000 r, Slaughter[6] reported pathological fractures of the ribs or clavicles in 8 patients who had received irradiation for carcinoma of the breast. In 5 of these the bone doses were only 1,500 to 3,100 r. Although these patients were only a very small proportion of the many hundreds who were similarly treated without conspicuous damage to bone, it is evident that, in an occasional patient, severe injury to bone may result following radiation doses which are safe in the majority of cases. It is probable that impairment of the blood supply of the bone owing to radiation fibrosis of adjacent soft parts is an important factor in these cases. If the regenera-

tive capacity of a bone is slightly impaired, it may still be able to maintain a normal structure provided adequate supplies of calcium and phosphorus are available. If, in addition, the blood supply is reduced, a combination of insufficient building materials and diminished ability to use them may result in a gradual loss of bone substance.

In summary, it appears that, in the adult, radiation therapy involving the delivery of doses in excess of 3,000 r to bone should not be used for benign lesions, because of the danger of damage to the regenerative capacity of the bone. For malignant lesions, doses up to 4,000 r may be used in the expectation that the bone, although permanently damaged, will retain a considerable degree of useful function. Radiation doses much higher than this may be expected to cause such severe damage to bone that the final results will range from the unsatisfactory to the disastrous. In children, irradiation of bone for benign lesions should be done with extreme caution or not at all, because of the danger of causing crippling or disfiguring retardation of growth. For malignant lesions, where limitation of growth is of secondary importance, bone doses as high as 5,000 r may often be given with preservation of useful function.

We have spent some time in outlining the different methods of treating the various types of neoplastic disease of bone by roentgen rays. We have pointed out the danger of giving inadequate doses to radioresistant tumors, and, on the other hand, of giving excessive doses to radiosensitive tumors, thus preventing adequate bone regeneration.

We now wish to give another warning. We have recently observed the development of osteogenic sarcoma in 2 patients with giant cell tumor and 3 others with bone cyst that had apparently been successfully irradiated some ten or fifteen years ago. There are two explanations to be offered: First, it is possible that the tumor which was apparently cured by radiation therapy was in reality only arrested and later underwent malignant transformation. This seems unlikely, however, especially in the cases of bone cyst as the latter do not possess a tendency to such alteration spontaneously. Second, there is a possibility that heavy irradiation administered to bone over short periods of time may induce malignant change in a manner analogous to that in which the radiation from radium deposited in bone, acting at low intensities over periods of years, has been shown to have caused the development of osteogenic sarcoma in radium dial workers.

SUMMARY

The following table summarizes the results observed in this study. It must be emphasized that the figures given are for doses which have been found to produce a

Table I

TISSUE DOSES IN ROENTGENS USUALLY REQUIRED TO INACTIVATE BONE TUMORS AND BONE REGENERATION

Tissue	Dose Without Demonstrable Effect	Dose Causing Temporary Inactivation	Dose Causing Prolonged Inactivation	Dose Causing Complete Devitalization
Osteogenic sarcoma	<3,000 r	3,000–4,000 r	4,000–6,000 r	?8,000 r
Reticulum cell sarcoma of bone				3,000–4,000 r
Endothelioma of bone			3,000–5,000 r	?6,000 r
Giant cell tumor	?<800 r		1,000–2,000 r	1,500–3,000 r
Regeneration of normal adult bone	<2,000 r	2,000–3,000 r	3,000–4,000 r	5,000 r

given response in the average case. The individual case may respond somewhat differently owing to variations in the activity of the disease, the general condition of the patient, and the circulation in the affected part. Nevertheless it is hoped that the table may be of some assistance in planning the radiation therapy of bone tumors.

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PROMINENT INNER MALLEOLUS

A CAUSE OF PAINFUL AND ENLARGED ANKLE REGION

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AN ABNORMAL prominence of the inner malleolus of the tibia was noted in each of 10 soldiers who had complained of recurrent pain and swelling of a single ankle. While a prominence of the inner malleolus and the head of the astragalus is frequently noted in instances of pronated feet, these soldiers presented no abnormality of their feet. The 10 soldiers sought permission to wear low-quarter instead of regular "G.I." shoes. They had experienced local pain and swelling in the ankle region on wearing high shoes especially in the performance of military training.

In order to determine the variations in the configuration of the inner malleolus of the ankle, we examined and roentgenographed 100 ankles of 50 soldiers who had no complaints referable to their feet or ankles. This paper is presented first, to disclose the findings of such an investigation and second, to discuss the clinical significance of abnormal prominence of the inner malleolus as was observed in 10 patients.

STUDY OF 100 NORMAL ANKLES (CONTROL)

The examination was made of the ankles of 50 soldiers from eighteen to thirty-five years of age, who presented no obvious disturbances of the feet or ankles. Roentgenographic examinations were made of the ankles in the standing weight-bearing attitude.

The clinical and roentgenographic examination of these 100 ankles demonstrated a wide variation in the contour of the so-called normal inner malleolus (Fig. 1).

FIG. 1. Photographs and roentgenograms of the feet of 3 soldiers selected from the group of 50 to show the three main types of inner malleoli. The photographs and roentgenograms were made in the standing weight-bearing attitude. *A*, photograph shows a flat inner malleolus. *A'*, roentgenogram of these feet shows the absence of bowing of the tibiae and a flat inner malleolus. *B*, photograph of another soldier reveals a moderately prominent inner malleolus. Note the slight outward bowing of the distal third of the tibiae. *B'*, roentgenogram of the ankles illustrated in *B* shows a mild outward bowing of the tibiae. Note the moderately prominent inner malleoli. *C*, photograph reveals a marked outward bowing of the distal third of the tibiae, with very prominent inner malleoli. *C'*, roentgenogram shows the bowing of the tibiae and the abnormal tilting of the articular surfaces of the astragalus and tibia. Note the prominent inner malleoli.

When lateral bowing of the distal third of the leg was present, the outline of the inner malleolus appeared to be unduly prominent. On the other hand, when the contour of the leg was straight, the projection of the inner malleclus was barely perceptible. In none of these 100 ankles was there any evidence of soft tissue thickening over the inner malleolus.

Tracings were made of the outline of the bones of the ankle region as was revealed by roentgenographic examinations. Two determinations were made on these roentgen film tracings, one to estimate the angle of the projection of the inner malleolus (malleolar angle) and the other to determine the relative width of the inner malleolus (malleolar width index)* (Fig. 2).

Tables I and II summarize the findings:

TABLE I

Malleolar angle as noted in 100 ankles	
30 per cent of 100 ankles	30 degrees (malleolar
27	24 angle)
18	28
9	22
9	20
4	34
3	32

TABLE II

Malleolar width index as noted in 100 ankles	
22 per cent of 100 ankles	14/16 inch (malleolar
21	13/16 width index)
21	12/16
12	15/16
8	16/16
7	11/16
7	10/16
1	9/16
1	17/16

* Measurements were made as follows: a horizontal line parallel to the upper or lower edge of the roentgen film is drawn (A–A′) in the region of the articular surface of the distal end of the tibia. A perpendicular to this line (B–B′) is drawn at a point on the inner cortex 4 inches proximal to (A–A′). (At this level the diameter of the tibia is usually the same as that of the mid-shaft region.) Another line (C–C′) is drawn parallel to (B–B′), at the outermost portion of the inner malleolus. The distance between (B–B′) and (C–C′) is the "malleolar width index." Another line (D–D′) drawn to bisect approximately the inner malleolus, intersects line (B–B′). The angle B′OD′ is the "malleolar angle."

On the basis of these studies, we observed that a "malleolar angle" of 30 degrees was most common as was a "malleolar width index" of 14/16 of an inch. It is evident that these measurements are approximate because of the inherent difficulties in making comparisons of the various roentgenograms.

STUDY OF THE 10 PATIENTS WITH PROMINENT PAINFUL INNER MALLEOLI

History and Physical Findings. Five of the 10 patients with requests for permission to wear low-quarter shoes had suffered from a sprain or fracture to one of their ankles. This had occurred from three to fifteen years prior to their first visit to the orthopedic clinic. At the present time, these 5 soldiers complained of pain and swelling of a single ankle which was aggravated by the wearing of high shoes and the pursuit of military duties. In civilian life, they had worn low-quarter shoes and had experienced only a minimal degree of pain and swelling of the ankles.

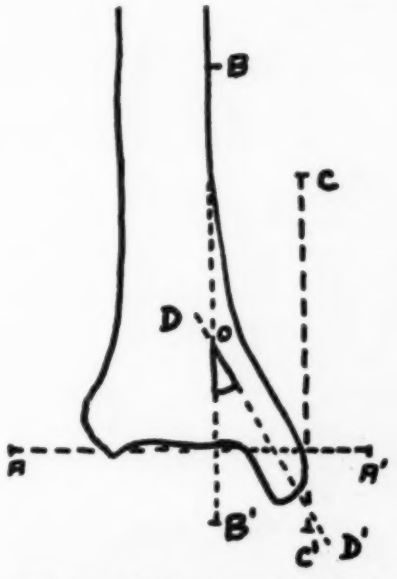

FIG. 2. A tracing of the contour of the distal end of a tibia. See footnote for interpretation of this diagram.

Physical examination of these 5 patients

disclosed in each a single tender prominent inner malleolus with normal mates. No evidence of any subcutaneous bursae was found over these inner malleoli. Furthermore, there was no unusual lateral bowing of the distal portions of the corresponding legs. Each of these 5 patients disclosed a total of 5 to 10 degrees of restriction in the range of active and passive dorsiflexion at the affected ankle. However, the movements of the opposite ankles were within normal limits.

The 5 other patients who did not suffer from trauma to their ankles, complained of occasional pain and swelling of a single ankle for periods ranging from two to five years prior to their first visit to this orthopedic clinic. In civil life these 5 soldiers had less local discomfort for they too had always worn low-quarter shoes. On examination at the present time, one noted a definite tender prominence of the inner malleolar region which was in part the result of a thickening of the overlying soft tissues. The opposite inner malleoli were less prominent, for they did not present any soft tissue swellings. No restriction in motion was observed either in the ankle joints or in the joints of the feet of the 5 patients in question.

Fig. 3. *A*, photograph of patient who suffered from a trauma to his left ankle approximately ten years ago. Note the prominent inner malleolus of this ankle. *B*, roentgenogram of the left ankle of this patient shows a hook-like projection on the inner malleolus. Note the soft tissue swelling.

Fig. 4. Roentgenogram of the ankle of another patient shows a hook-like projection on the inner malleolus as well as an ossicle of bone (os subtibiale). This patient also suffered from trauma to the part about fifteen years ago.

Roentgenographic Examination. In each of the 5 patients who suffered from previous trauma to a single ankle, roentgenographic examination disclosed irregularity in the contour of the affected inner malleolus as well as an enlargement of the part. Hook-like projections which were formed by periosteal proliferation in the region of the inner malleolus almost assumed the ap-

pearance of osteomas (Fig. 3). In 1 of the 5 there was present in addition to those periosteal changes evidence of a unilateral accessory bone (os subtibiale) over the tip of the affected inner malleolus (Fig. 4).[1,2,3,4] As for the measurements of tracings of the pathologic inner malleoli of these 5 cases, the "malleolar angle" ranged from 30 to 35 degrees and the "malleolar width index" from 16/16 to 18/16 inch—readings considered abnormal as compared to the standards observed in the study of the 100 ankles. The readings of the "malleolar angle" and "the malleolar width index" of the *opposite* ankles in these 5 patients were within normal limits and no abnormal changes were seen in the contour of these inner malleoli.

Roentgenographic examination of the ankles of the 5 patients, who did not experience any local trauma, revealed in 1 of the 5 the presence of anomalous flat sessile mounds on the attenuated cortices of the right and left inner malleoli. Three other patients presented either trapezoid configuration or lateral bowing of the distal portions of both tibiae. The fifth patient showed a trapezoid configuration of the distal end of one tibia (Fig. 5). These 5 patients demonstrated on roentgen examination a "malleolar angle" or "malleolar width index" just above the average figures. Subcutaneous soft tissue swellings were present only over the painful inner malleolus in each of these 5 and they formed a good part of the local prominence.

Fig. 5. Roentgenogram of both ankles taken in the standing weight-bearing position shows the enlargement and prominence of the left inner malleolus and thickening of the overlying soft tissue. There is a definite trapezoid configuration of the distal portion of the tibia. No history of trauma to the part.

TREATMENT

In each one of the 10 patients, we prescribed low-quarter shoes in order to lessen irritation to the prominent inner malleolus. The application of hydrotherapy or infrared radiation to the local swelling and the limitation of military duties resulted in definite alleviation of pain and diminution in size of the soft tissue swelling.

DISCUSSION

The study of a 100 so-called normal ankles has shown that the contour as well as the angle of projection of the inner malleolus varies considerably. When the inner malleolus has a high "malleolar angle" or a high "malleolar width index," or both, irritation of the contiguous overlying soft tissues may be caused by high shoes or boots. It is of interest that in the series of 100 ankles we found the absence of local soft tissue swelling even in the presence of a prominent inner malleolus. The angle of projection of the inner malleolus (malleolar angle) may be considered analogous to the attitude of the first metatarsal bone as the basis for bursal formation over the bony prominences at either the metatarsophalangeal articulation or inner malleolus, respectively. Therefore, if the inner malleolus is unduly prominent, subcutaneous bursae may be caused by irritation of the overlying high shoe or boot. Noteworthy is the finding that roentgen examinations of the ankle made in the weight-bearing attitude revealed that in 10 per cent of the controls the articular surfaces of the talotibial articulation were in an oblique rather than in a horizontal plane. The articular surface near the inner malleolus was on a higher level than that at the outer malleolus. Such obliquity is the

result of a lateral bowing of the distal third of the tibia and this caused a relative prominence of the inner malleolus.

In one instance where we observed a reverse tilt of the articular surfaces of the talotibial articulation, wherein the articular surface near the outer malleolus was on a higher level than that near the inner malleolus, the latter was barely palpable.

As for the 5 patients who had suffered previously from severe trauma to the ankle, the prominence and enlargement of the affected inner malleolus was the result of proliferation of new periosteal bone. Most of these injuries had occurred during the period of growth in the age group of eleven to sixteen years, when proliferation of bone is most active.

CONCLUSION

Unusual prominence of the inner malleolus of the tibia may be the cause for recurrent pain and swelling of an ankle, especially over its medial aspect. Such changes in the inner malleolus may be the result of previous trauma, with secondary irritation of the local periosteal and ligamentous tissues, especially when it had occurred during the active growth period of the skeleton. Other causes for such a prominence—developmental in character and not associated with trauma—are lateral bowing of the distal third of the tibia and a trapezoid configuration of the distal end of the tibia. In this group, the presence of a subcutaneous bursa over the prominent inner malleoli was a frequent finding when symptoms were present.

Based on a clinical and roentgenographic examination of one hundred so-called normal ankles, we observed a wide variation in the contour of the inner malleolus. By measurement of tracings of the roentgenograms of these one hundred ankles, we noted that the average "malleolar angle" was 30 degrees and the average "malleolar width index" was 14/16 of an inch. Readings higher than these average findings indicated that the inner malleolus was prominent and that it should be considered as a possible cause of pain and swelling of the part.

In this investigation, we have studied ten soldiers with tender and prominent inner malleoli. Five of the swellings were produced by trauma to the part and the other five were caused by abnormalities in the contour of the tibia. These ten men were unable to wear high shoes because of the irritation of the prominent part. When they were granted permission to wear low-quarter shoes, a rapid resolution of the soft tissue swellings and pain of the affected ankle was observed. In no instance, however, was the intrinsic shape or contour of the inner malleolus modified by this treatment.

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APPEARANCE AND GROWTH OF OSSIFICATION CENTERS AND INCREASES IN THE BODY DIMENSIONS OF WHITE AND NEGRO INFANTS

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FOUR decades ago it was noted that full-term negro infants in the United States weighed less at birth than the white infants,[45] an observation which was verified by later investigators.[2,6,9,14,29] During the first year of life white infants weigh more than negro infants, on the average, and for each racial group the average weight of male infants is greater than the average for females.[6,14] Some investigators have observed shorter gestation periods for negro women than for white mothers[26] and suggested that this may account for the smaller birth weights of negro infants.

Observations on the growth of infants during the first year of life have indicated that negro infants not only weigh less at birth than white infants but also that they grow more slowly.[6] Bakwin and Patrick,[5] however, after observing a negro group, made up of private patients in contrast to dispensary patients, recently stated: "There is no significant difference in the weight gain of white and negro infants during the first year of life. It seems likely that the slower growth observed in the earlier studies was due to differences in socioeconomic status rather than to the differences in the nature of the germ plasm. Given the opportunity of proper medical supervision, Negro infants from moderate income families grow as well as white infants."

The Department of Health of New York City during the past decade has applied special dietary and general health supervision in behalf of indigent infants, both white and negro. As a result, manifold improvements[30] can be recorded in the general health of both races, but the negro still has greater illness which can be linked up with his poorer economic status. In discussing the higher death rates among negroes, Dublin[13] states: "It does not appear that there is such a thing as absolute racial immunity to any disease. But color, doubtless, does exert more or less influence over the prevalence of, and the death rate from many diseases. Just how much of this influence is due to racial immunity or susceptibility, and how much to racial customs economic status, and environment, is very difficult to determine. The factor of the 'crossing' of the white and Negro races also beclouds the issue—since the mulatto, the octoroon, etc., are classified as 'colored'. "

Numerous studies have shown effects of diet and environment on the mother and fetus during gestation and nutritional imprints upon the offspring.[4,11,16] Burke, Harding and Stuart[11] found a significant relationship "between the protein content of the mother's diet during pregnancy and the birth length of her infant. This increase in birth length can be demonstrated with each additional increment of protein in the prenatal diet irrespective of mother's height." Ebbs[16] has stated: "The ideal normal nutritional state for pregnancy would be one in which the maternal body was endowed with the proper nutritional elements before, during and after the pregnancy, to ensure the optimum needs of the fetus in its intra-uterine development, to supply stores for its needs in early infancy, to ensure adequate nutrition for the normal physiologic requirements of the mother, and for the added requirements resulting from pregnancy and lactation. It is there-

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fore not enough to discuss the question of diet for the expectant mother by simply saying that her needs are those of any healthy woman. While we have been accustomed to thinking of the fetus as parasitic and therefore obtaining its nutritional needs even at the expense of the maternal stores, perhaps we should consider more optimum development of the fetus by making all needs readily available."

Even if the "ideal normal nutritional state for pregnancy"[15] were achieved among negro women to a degree comparable to that prevalent among white mothers, it is likely that the full cumulative effect of racial customs and environmental conditions upon many generations could not be neutralized within a single lifetime. From many approaches efforts are being exerted to improve the socio-economic status of the negro and it is important to know any developmental characteristics owing to race differences so that the growth of children of both races can be judged by appropriate standards.

Hess and Weinstock[24] twenty years ago pointed out that the phase of osseous development of newborns varies with both sex and race. In his nutritional study of causes for greater susceptibility to rickets by the negro race, roentgenograms were made of the wrists of the newborn infants of 500 white and negro mothers of about the same socio-economic status. A carpal center was found to be present in 10 per cent of the white male babies and in over 22 per cent of the white female babies, a difference which other investigators have reported in older infants. Hess and Weinstock found that these centers were to be seen much more frequently in negro than in white babies, reaching in the negro female babies an incidence as high as 40 per cent. They state that "this distinction is one which exists quite apart from the factors of sex or of birthweight. In respect to weight, conditions favored the white infants: for the larger the baby the more prone it is to develop centers early . . . the birthweight of the white babies was decidedly greater on the average than that of the negroes . . . It is difficult to judge whether this precocious maturity of the negro, this early development of carpal centers, bears a relationship to the remarkable susceptibility of this race to rickets."

Comparative studies of the appearance and growth of ossification centers and the dimensions of the bones in white and negro infants have not been made. The early investigations of ossification, those of Pryor[36] in 1905 and of Rotch[46] in 1909, were roentgenological studies of the age of appearance of various centers in white infants. These were followed by other investigations of the age of appearance, those of Adair and Scammon,[1] Flecker,[18] Francis and Werle,[20] Menees and Holly,[28] Paterson,[32] Pryor,[37–41] Pyle and Sontag,[42] E. L. Reynolds,[44] and Sontag, Snell and Anderson.[49] Francis[19] investigated also the factors influencing the appearance of centers of ossification.

Stages of ossification in fetuses of various ages and both sexes have been reported by Brailsford,[10] Flecker,[17] Hill,[25] and Spencer.[50]

Maresh and Deming[27] reported growth of long bones, and Washburn's values for radial length were reported by Woolley and McCammon.[53]

Comparisons of the external dimensions of white and negro infants have been published. Dunham, Jenss and Christie[14] considered race and sex in relation to weight and found that females weighed less than males at birth and that white infants weighed more than negro infants. She also pointed out that the cuboid was present more frequently in newborn negroes than in whites of the same birth weight, and for each race the cuboid was present more frequently in females than males. Bakwin[3] reported the birth weights of white males as highest, those of white females next, negro males next, while negro females weighed the least.

EXPERIMENTAL

Roentgenograms and measurements obtained during an investigation of the

growth of white and negro infants provided an opportunity to study the appearance and growth of centers of ossification and increases in body size in relation to race and sex. The infants were from homes of low socio-economic level but did not show abnormality on clinical examination. Most all of the babies were artificially fed after they were two to six weeks old. Throughout their first year of life the babies received medical care from pediatricians cooperating in the study and adequate diets were supplied for them, consisting of a formula of evaporated milk, water and corn syrup, acidified with dehydrated lemon juice. Vitamin D was supplied either by cod liver oil or by irradiated milk. Solid foods were added to the diet in the amounts and at the ages customary in pediatric practice. Four hundred and twenty-five infants, of which 174 and 131 were white male and female infants, and 55 and 65 were negro male and female infants, respectively, were observed at approximately twenty-eight day intervals during their first year of life. Some of the babies were followed through their second and third years. Data for those years are given in this paper but no conclusions are drawn from them. Other papers give the details of the study and show the quantitative relations between the blood cells and hemoglobin,[22] the hemoglobin differences between the white and negro infants,[31] the relationship between height and weight of the male and female infants[42] and between vitamin D intake and linear growth,[48] the vitamin C intakes,[23] the thiamine intakes and psychometric evaluations[12,34] and the effect of the addition of vegetables to the infants' diets.[35]

At each examination, in addition to weight, roentgenograms were obtained for measuring areas and dimensions of bone structures and various external measurements were made. In addition to determining the norms for the entire group of infants, the data were separated as to race and sex to determine whether there were significant differences between the infants of the negro and white races.

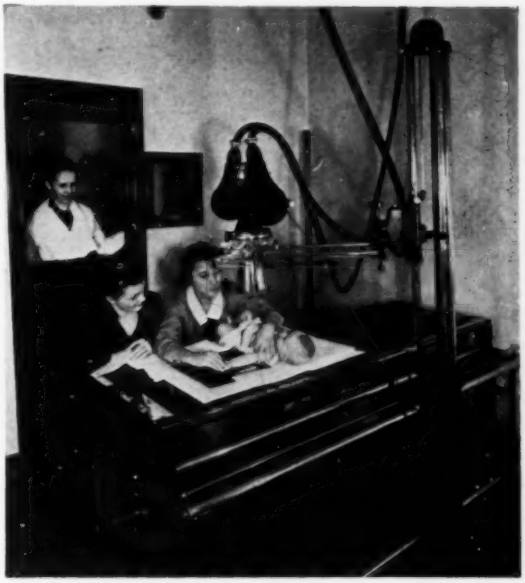

Fig. 1. Showing method of obtaining roentgenogram of elbow.

ORDER OF APPEARANCE OF OSSIFICATION CENTERS

During each examination, roentgenograms were made of the left foot, leg, forearm and hand. A posterior view of the hand and an anterior view of the foot were taken at a distance of 26 inches, with 40 ma., 35 volts, 9/20 second. The hand, palm down, and forearm were placed on the table for exposure. The roentgenogram of the foot was obtained with the child on his back, knee flexed, the sole flat against the table. The anterior view of the left forearm was taken at a distance of 26 inches, with 40 ma., 40 volts, 9/20 second, with the hand, palm up, and arm resting on the table (Fig. 1). In this position the radius and ulna do not cross. The posterior view of the left leg was taken at a distance of 26 inches, with 40 ma., 45 volts, 9/20 second, with the child face down, leg resting extended on the table.

The centers observed in the roentgenograms* were listed in groups and then were ranked in the order of their appearance

* To avoid duplication, Gray's[21] terminology has been used for the carpal bones and Piersol's[33] for the tarsal bones.

Table 1

ORDER OF APPEARANCE OF OSSIFICATION CENTERS IN THE HANDS OF MALE AND FEMALE WHITE AND NEGRO INFANTS

Number of male infants from total of 174 white and 55 negro

		First		Second		First Two		Third		Second and Third		First Three		Fourth		Third and Fourth		Second Third and Fourth	
		W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N
Carpus																			
Hamate		8	1	53	6	91	44	—	—	1	—	3	1	—	—	—	—	9	—
Capitate		63	6	7	1	91	44	—	—	—	—	3	1	—	—	—	—	1	—
Lunate		—	—	—	—	—	—	—	1	—	—	—	—	34	14	121	37	10	—
Triangular		—	—	—	—	—	—	30	13	1	—	3	1	—	1	121	37	10	—
Tarsus																			
Scaphoid		—	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	—	—
Cuboid		136	31	—	1	33	23	—	—	—	—	—	—	—	—	—	—	—	—
Cuneiform																			
External		—	—	120	25	33	23	—	—	—	1	—	—	—	—	—	—	—	—
Middle		—	—	—	—	—	—	1	1	—	—	—	—	1	—	2	2	—	—
Internal		—	—	—	—	—	—	12	7	—	—	—	—	—	2	4	2	—	—
Hand																			
Metacarpals	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	—	—	—	—	2	2	—	—	—	—	2	—	—	—	—	1	1	—
	3		—	—	1	—	2	—	—	—	—	1	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Proximal phalanges	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	3	1	—	—	7	1	—	—	2	—	6	—	1	3	2	—	—	—
	3	10	2	1	1	9	—	—	3	—	—	7	1	—	—	—	1	1	—
	4	—	—	2	2	3	—	—	—	3	1	5	1	1	—	1	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Middle phalanges	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Distal phalanges	1	9	4	—	—	3	1	1	—	1	1	3	1	1	—	—	—	1	—
	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—
	4	—	—	—	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Number of female infants from total of 131 white and 65 negro

Carpus																			
Hamate		3	4	19	9	98	42	—	—	1	2	1	5	—	—	—	—	5	1
Capitate		25	12	3	4	98	42	—	—	—	—	1	5	—	—	—	—	—	—
Lunate		—	—	—	—	—	—	—	—	—	—	—	1	35	21	87	40	5	1
Triangular		—	—	—	—	—	—	33	15	1	2	1	4	—	1	87	40	5	1
Tarsus																			
Scaphoid		—	—	—	—	—	—	3	1	—	—	—	—	1	—	1	—	—	—
Cuboid		94	39	—	—	36	25	—	—	—	—	—	—	—	—	—	—	—	—
Cuneiform																			
External		—	—	81	37	36	25	—	—	1	—	—	—	—	—	—	—	—	—
Middle		—	—	—	—	—	—	1	4	—	—	—	—	4	1	12	4	—	—
Internal		—	—	—	—	—	—	24	12	1	—	—	—	1	2	11	4	—	—
Hand																			
Metacarpals	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	—	1	—	1	1	1	—	—	2	—	1	1	—	—	—	—	1	—
	3	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Proximal phalanges	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	3	—	1	1	10	1	1	2	10	4	16	6	—	—	2	—	1	2
	3	7	6	3	1	17	3	1	—	4	—	16	8	1	—	—	1	2	1
	4	2	—	1	—	6	1	2	—	5	4	10	6	2	2	5	1	2	2
	5	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Middle phalanges	2	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
	3	—	—	—	—	1	1	1	—	—	—	—	1	—	—	—	—	—	—
	4	—	—	—	—	1	1	—	—	—	—	—	1	2	1	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Distal phalanges	1	9	5	—	—	3	3	—	—	1	—	5	4	3	—	5	—	—	1
	2	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
	3	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE I—*Continued*

Number of male infants from total of 174 white and 55 negro

First Four		Fifth		Fourth and Fifth		Third Fourth and Fifth		Second Third Fourth and Fifth		First Five		First Six		First Seven		First Eight	First Nine		First Ten		First Eleven	Av. Rank*	
W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	W	N	W	N	W	W	N
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3
—	—	3	3	12	7	136	39	16	5	—	—	—	—	—	—	—	—	—	—	—	—	5	5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	—	—	—	16	5	—	—	—	—	—	—	—	—	—	—	—	—	2	2
—	—	2	1	11	7	136	39	16	5	—	—	—	—	—	—	—	—	—	—	—	—	4	4
—	—	—	—	1	—	136	39	16	5	—	—	—	—	—	—	—	—	—	—	—	—	3	3
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	16	19
1	—	—	—	—	—	—	—	—	—	—	—	4	2	4	1	1	2	—	1	1	4	5	5
1	—	1	—	—	—	—	—	—	—	—	—	3	2	4	—	—	2	—	1	1	4	6	6
1	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	1	1	3	10	12
—	—	—	—	—	—	—	1	—	—	—	—	—	1	1	—	—	—	—	1	1	2	14	11
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	18	18
6	—	—	—	—	—	—	2	1	—	3	—	4	2	4	1	2	2	—	1	1	4	2	3
6	—	—	—	—	—	—	—	1	—	2	—	4	2	4	1	2	2	—	1	1	4	1	1
6	—	—	1	—	—	—	1	1	—	2	—	4	2	4	1	2	2	—	1	1	4	3	4
1	—	1	—	—	—	—	—	—	—	—	—	3	—	1	—	1	2	—	1	—	4	7	14
—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	2	—	—	—	—	1	12	13
—	—	—	—	—	—	—	1	—	—	3	—	—	—	—	—	2	2	—	—	1	3	8	9
—	—	—	—	—	—	—	1	—	—	2	—	—	—	—	1	2	2	—	—	1	3	9	7
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19	17
6	—	—	—	—	—	—	—	—	—	1	—	2	1	2	1	2	2	—	1	1	4	4	2
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15	15
—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	2	11	10
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	13	8
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17	16

Number of female infants from total of 131 white and 65 negro

—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3
—	—	15	7	21	13	77	41	12	2	—	—	—	—	—	—	—	—	—	—	—	—	5	5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	—	—	—	12	2	—	—	—	—	—	—	—	—	—	—	—	—	2	2
—	—	2	—	22	12	77	41	12	2	—	—	—	—	—	—	—	—	—	—	—	—	4	4
—	—	1	—	3	3	77	41	12	2	—	—	—	—	—	—	—	—	—	—	—	—	3	3
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15	16
—	—	—	—	—	2	—	1	—	—	—	1	3	1	—	1	—	1	1	1	—	1	7	5
—	—	1	1	—	1	—	2	—	—	—	1	3	1	—	—	—	—	1	1	—	1	8	8
—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	1	1	—	—	11	12
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	13	14
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	17	17
4	2	—	—	—	—	1	—	—	—	1	1	3	1	—	1	—	1	1	1	1	1	2	2
4	1	—	—	—	—	—	—	—	—	1	1	3	2	—	2	—	1	1	1	1	1	1	1
4	2	—	—	2	—	1	—	—	—	1	—	3	1	—	2	—	1	1	1	1	1	3	3
1	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	1	9	13
—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	1	1	10	11
—	1	—	—	2	1	—	1	—	—	1	—	—	1	—	2	—	1	—	1	1	1	6	7
—	2	—	—	4	1	1	—	—	—	1	—	—	1	—	2	—	1	—	1	1	1	5	6
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	1	16	19
3	—	1	—	3	2	—	1	—	—	—	1	3	2	—	—	—	1	1	1	1	1	4	4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	19	15
—	—	1	—	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	12	9
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	14	10
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18	18

TABLE II

ORDER OF APPEARANCE OF OSSIFICATION CENTERS IN THE FEET, ARMS AND LEGS OF MALE AND FEMALE WHITE AND NEGRO INFANTS

Number of male infants from total of 174 white and 55 negro

		First		Second		First Two		Third		Second and Third		First Three		Fourth		Third and Fourth		Second Third Fourth	First Four		Fifth	
		W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	W	N	W	N
Foot																						
Metatarsals	1	1	—	—	—	1	2	—	—	—	—	—	1	—	—	—	—	1	2	1	—	—
	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Proximal phalanges	1	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	4	1	—	—
	2	—	—	1	—	1	2	4	—	—	—	14	1	—	—	—	—	2	7	2	—	—
	3	9	1	—	—	7	1	—	—	—	—	14	—	—	—	—	—	—	7	2	—	—
	4	—	—	3	—	7	—	—	1	—	—	14	—	—	—	—	—	2	7	2	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—
Arm and leg																						
Femur—Distal		15	6	—	—	151	46	—	—	—	—	5	3	—	—	—	—	—	3	—	—	—
Tibia—Proximal		—	—	11	5	151	46	—	—	2	1	5	3	—	—	—	—	—	3	—	—	—
—Distal		—	—	—	—	—	—	40	10	1	—	—	—	30	5	78	23	—	3	—	—	1
Fibula—Proximal		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—Distal		—	—	—	—	—	—	—	—	—	—	—	—	3	—	2	—	—	—	—	26	6
Humerus*		—	—	—	—	—	—	31	7	1	1	5	3	25	5	76	23	—	3	—	2	—
Radius—Proximal		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
—Distal		—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	26	7
Ulna—Distal		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—

Number of female infants from total of 131 white and 65 negro

Foot																						
Metatarsals	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—
	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Proximal phalanges	1	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	1	1	—	—	—
	2	—	1	—	—	3	3	11	2	6	2	9	4	—	—	—	1	1	5	1	—	—
	3	24	4	1	—	16	9	—	—	1	—	9	4	—	—	—	—	—	5	1	—	—
	4	2	1	11	1	13	6	1	—	5	2	9	4	—	—	—	—	1	5	1	—	—
	5	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	1	1
Arm and leg																						
Femur—Distal		4	2	—	—	110	59	—	—	—	—	13	3	—	—	—	—	—	3	1	—	—
Tibia—Proximal		—	—	2	2	110	59	—	—	1	—	13	3	—	—	—	—	1	3	1	—	—
—Distal		—	—	—	—	—	—	17	6	1	—	2	—	28	10	51	25	1	3	1	—	—
Fibula—Proximal		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—Distal		—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	28	8
Humerus*		—	—	—	—	—	—	21	18	—	—	11	3	11	2	51	25	1	3	1	—	—
Radius—Proximal		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
—Distal		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—
Ulna—Distal		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* Capitellum

(Tables I and II). For some infants, two or more bones first appeared on the same roentgenogram. With these, no attempt was made to ascertain the order of appearance, the number of instances being listed in the tables under the first two, second and third, first three, etc. The average ranking for each of the bones is also given.

TABLE II—*Continued*

Number of male infants from total of 175 white and 55 negro

Fourth Fifth		Third Fourth Fifth		Second Third Fourth Fifth	First Five		Third Fourth Fifth Sixth		Second Third Fourth Fifth Sixth	First Six		Sixth		Fifth and Sixth		Seventh		Sixth and Seventh		Fifth Sixth Seventh	Seventh and Eighth	Av. Rank*	
W	N	W	N	W	W	N	W	N	N	W	N	W	N	W	N	W	N	W	N	W	W	W	N
—	—	—	—	1	3	—	1	—	—	3	1	—	—	—	—	—	—	—	—	—	—	4	3.5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	7.5	8.5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	7.5	8.5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9.5	8.5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9.5	8.5
—	—	—	—	—	2	1	1	—	—	3	1	—	—	—	—	—	—	—	—	—	—	5	3.5
—	—	—	—	1	3	1	1	—	—	3	1	—	—	—	—	—	—	—	—	—	—	3	1
—	—	—	—	—	3	1	—	—	—	3	1	—	—	—	—	—	—	—	—	—	—	1	2
—	—	—	—	1	3	1	—	—	—	3	1	—	—	—	—	—	—	—	—	—	—	2	5
—	—	—	—	1	1	1	1	—	—	3	1	—	—	—	—	—	—	—	—	—	—	6	6
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
4	2	5	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	4
—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	8	9
6	2	2	—	—	—	—	—	—	—	—	—	17	3	28	6	—	—	1	1	1	—	5	6
5	1	4	3	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	4	3
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	7
3	3	3	3	—	—	—	—	—	—	—	—	15	3	30	6	—	—	1	—	1	—	6	5
—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	—	1	1	1	7	8

Number of female infants from total of 131 white and 65 negro

—	—	1	—	—	3	2	3	—	1	4	3	—	—	—	—	—	—	—	—	—	—	4	5
—	—	—	—	—	—	—	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	7	7
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	8
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9	9
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	10
—	—	1	1	—	3	2	3	—	1	4	3	—	—	—	—	—	—	—	—	—	—	5	4
—	—	1	1	—	3	2	3	—	—	4	3	—	—	—	—	—	—	—	—	—	—	3	3
—	—	—	—	—	3	2	—	—	1	4	3	—	—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	3	2	—	—	1	4	3	—	—	—	—	—	—	—	—	—	—	2	2
1	—	—	1	—	—	—	2	—	1	4	1	—	—	—	—	—	—	—	—	—	—	6	6
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	2
1	3	12	5	—	—	—	1	3	—	—	—	—	—	—	—	4	—	—	—	—	—	4	4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	1	7	8.5
3	—	6	—	—	—	—	1	3	—	—	—	14	13	34	9	—	—	—	—	1	—	5	6
3	1	12	5	—	—	—	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3
—	4	—	5	—	—	—	—	3	—	—	—	—	6	—	9	—	—	1	—	—	1	8	8.5
1	—	6	—	—	—	—	1	—	—	—	—	22	—	34	—	—	—	—	—	1	—	6	5
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	9	7

Of the four carpal bones present at these ages the capitate appeared first, the hamate, second, the triangular, third and the lunate, fourth. Though the order of the capitate and hamate sometimes interchanged, the triangular and lunate bones were in the third and fourth places, respectively, except in one negro male and one

Fig. 2. The precision disc planimeter. (Courtesy *Am. J. Dis. Child.*, 1937, *54*, 726.)

negro female in whom the lunate bone appeared before the triangular.

In 78 of 94 white male babies studied at Western Reserve University,† the capitate appeared first, a ratio of 4.9 to 1. In the present series, the capitate appeared first in 63 of 71 infants, a ratio of 7.9 to 1; however, in 94 additional cases both the capitate and hamate were present on the first roentgenogram or appeared during the same interval. Observation of size and maturity indicators‡ on the roentgenograms of 86 infants in this group indicated that the capitate appeared first in 66 instances. Thus, of a total of 157 infants the capitate appeared first in 129, a ratio of 4.6 to 1.

As the calcaneum and astragulus were present on every roentgenogram no attempt was made to determine which tarsal appeared first. Rankings for the two bones were omitted from Table 1. Of the remaining five, the cuboid bone appeared first, followed by the external cuneiform in every infant except one negro male. There appeared to be more irregularity in the negro than in the white infants. The scaphoid, middle cuneiform and internal cuneiform were observed in any rank from the third to the fifth. The internal cuneiform was found more frequently in third place, the middle cuneiform in fourth place and the scaphoid appeared oftener in the fifth place than any other bone.

Nineteen bones of the hand are ranked in Table 1 according to the appearance of the five epiphyses of the metacarpals, of the proximal and distal phalanges and of the four middle phalanges. Though there is much variation in the order of appearance, the displacement from the average rank of the bone is never more than a few places. The epiphyses of the second and third metacarpal, of the second, third and fourth proximal phalanges and of the first distal phalanx are among the first to appear. The average ranking of each of the epiphyses of the hand varies little for male versus female or white race versus black race.

The order of appearance of the epiphyses of the five metatarsals and proximal phalanges varied, though the epiphyses of the first metatarsal and of the second, third and fourth proximal phalanges were always among the first to appear (Table II).

The appearance of the distal epiphyses of the femur, tibia, fibula, radius and ulna, the proximal epiphyses of the tibia, fibula and radius, and the capitellum ranked as shown in Table II. The distal epiphysis of the femur appeared first and the proximal epiphysis of the tibia appeared second in all cases. The distal epiphyses of the tibia and the capitellum shared the third and fourth places.

The rankings of the centers of the hand, foot, forearm and leg varied only slightly from one to another of the four sex and race groups and the displacement was never more than a few places.

CARPAL AREAS OF WHITE AND NEGRO, MALE AND FEMALE INFANTS

The area of each carpal bone present on the roentgenograms of the infants was determined with a precision disc planimeter (Fig. 2) made by G. Coradi, Zürich. The mean size of the individual carpal bones and the percentages of the groups of children with the various carpal bones present at different ages are given in Tables III and IV. The measurements made from the

† Data furnished by S. Idell Pyle, M.S., Research Associate, Department of Anatomy, Western Reserve University, Cleveland, Ohio.

‡ Determined by S. Idell Pyle, M.S., Research Associate, Department of Anatomy, Western Reserve University, Cleveland, Ohio.

TABLE III

MEAN CARPAL AREAS FOR MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age, days	Subjects				Capitate				Hamate				Lunate				Triangular			
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Female	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
	No.	No.	No.	No.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.	sq. mm.
1–14	3	2	—	1	0	0	—	0	0	0	—	0	0	0	—	0	0	0	—	0
15–28	41	13	29	18	0.9	0.9	2.3	1.5	0.5	0.6	2.3	1.0	0	0	0	0	0	0	0	0
29–56	94	29	79	36	1.2	2.3	1.7	4.3	0.7	1.8	1.3	3.5	0	0	0	0	0	0	0	0.1
57–84	53	20	50	18	3.9	3.7	5.6	6.6	2.0	3.0	3.9	4.7	0	0	0	0	0	0	0	0.4
85–112	43	11	34	15	7.3	6.5	9.6	11.7	4.0	5.3	6.7	8.7	0	0	0	0	0	0	0.2	1.1
113–140	62	14	41	16	9.4	13.1	10.9	14.0	5.8	8.7	7.7	11.0	0	0	0	0	0.1	0	0.4	1.2
141–168	70	18	51	17	11.7	15.8	13.9	18.5	7.0	9.2	10.2	13.3	0	0	0	0	0	0	0.5	2.1
169–196	142	42	107	54	14.0	17.7	14.9	18.2	8.7	12.6	10.9	13.2	<0.1	0	0	0.1	0.3	0.4	0.4	1.1
197–224	80	32	57	30	17.0	19.9	17.0	21.8	11.1	13.8	12.2	15.6	0	0	0	0.4	0.2	0.7	0.6	1.7
225–252	85	38	58	29	18.8	21.1	18.8	24.3	12.2	15.0	13.6	18.0	0	<0.1	0	0.4	0.5	0.8	0.8	2.1
253–280	95	31	69	34	20.1	24.4	20.5	25.9	13.1	18.0	15.0	18.5	0	0.1	0	0.4	0.4	1.5	0.8	2.3
281–308	91	30	59	30	22.3	25.9	22.6	27.7	14.8	18.0	16.5	20.3	0	0.1	0	0.7	0.6	1.3	1.1	2.8
309–336	89	27	59	26	23.6	27.2	24.2	29.6	16.0	19.2	17.7	22.2	<0.1	0	<0.1	0.6	0.7	1.8	0.9	3.9
337–364	90	25	62	26	25.5	28.6	26.4	32.5	17.6	20.8	19.3	22.4	<0.1	0.1	<0.1	0.9	1.0	1.7	1.1	3.1
365–392	34	12	26	18	23.8	30.4	26.8	31.3	16.2	20.9	19.9	25.1	0	0.1	0	0.2	0.8	2.6	1.4	3.5
393–420	5	—	3	—	26.0	—	36.5	—	16.2	—	26.5	—	0	—	0	—	0	—	0	—
421–448	—	2	2	—	—	22.9	24.1	—	—	16.6	14.2	—	—	0	0	—	—	0	0	—
449–476	3	—	—	—	26.1	—	—	—	19.9	—	—	—	0	—	—	—	0	—	—	—
505–532	1	—	—	—	40.2	—	—	—	31.0	—	—	—	0	—	—	—	15.8	—	—	—
617–644	—	—	—	1	—	—	—	46.5	—	—	—	43.8	—	—	—	0	—	—	—	15.0
645–672	—	1	—	—	—	34.2	—	—	—	25.2	—	—	—	0	—	—	—	0	—	—
673–700	2	1	—	—	34.6	37.2	—	—	30.7	38.7	—	—	0	0	—	—	0	0	—	—
701–728	9	2	5	2	38.8	48.0	44.2	49.1	25.8	38.4	31.3	33.5	0	0	0	0	2.7	0.2	3.1	2.1
729–756	16	2	9	4	36.9	45.7	44.3	49.4	26.2	33.0	31.7	31.7	0	0	1.2	0.2	1.4	5.8	4.0	4.1
757–784	3	—	1	2	45.2	—	53.0	43.5	34.1	—	32.8	29.8	0.3	—	0	0	5.7	—	9.0	5.1
785–812	2	—	2	1	47.4	—	55.3	61.2	35.3	—	40.8	45.0	0	—	0	0	0	—	3.0	21.3
813–840	4	—	3	—	56.5	—	45.3	—	37.1	—	33.1	—	4.6	—	0	—	6.0	—	1.4	—
841–868	3	1	5	—	53.8	43.7	54.8	—	29.6	28.0	36.6	—	0	0	2.1	—	6.6	7.3	9.4	—
869–896	4	1	1	1	60.8	45.8	53.7	52.2	44.6	31.0	44.0	41.7	0	0	0	12.7	8.4	0	1.8	17.8
897–924	3	—	1	—	49.5	—	57.5	—	36.9	—	40.3	—	1	—	0	—	8.3	—	13.0	—
925–952	2	—	3	—	60.2	—	48.4	—	35.0	—	37.5	—	0	—	4.1	—	0	—	15.6	—
981–1008	1	1	—	—	66.0	48.2	—	—	49.8	41.8	—	—	0	0	—	—	28.8	0	—	—
1009–1036	1	—	—	—	76.0	—	—	—	52.2	—	—	—	0	—	—	—	0	—	—	—
1205–1232	—	—	1	—	—	—	60.0	—	—	—	44.2	—	—	—	0	—	—	—	0	—

Table IV

PRESENCE OF CARPALS IN MALE AND FEMALE WHITE AND NEGRO INFANTS

Per cent occurrence in age groups

Age, days	Capitate				Hamate				Lunate				Triangular				Greater Multangular	Navicular
	Male		Female		Male		Female		Male		Female		Male		Female		Female	Female
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	Negro	Negro
1–14	0	0	—	0	0	0	—	0	0	0	—	0	0	0	—	0	0	0
15–28	20	23	59	50	15	23	52	33	0	0	0	0	0	0	0	0	0	0
29–56	26	41	39	67	13	41	34	58	0	0	0	0	1	0	0	6	0	0
57–84	57	65	76	72	38	50	58	67	0	0	0	0	0	0	2	17	0	0
85–112	74	82	94	100	63	73	82	100	0	0	0	0	0	0	9	33	0	0
113–140	84	93	88	88	64	78	78	94	0	0	0	0	5	7	12	25	0	0
141–168	88	100	98	100	78	83	92	94	0	0	0	0	4	6	14	35	0	0
169–196	92	98	97	100	84	98	93	96	0.7	0	0	4	6	14	10	24	0	0
197–224	98	100	98	100	91	100	95	100	0	0	0	7	10	16	10	30	3	0
225–252	99	97	100	100	95	97	98	100	0	3	0	7	13	21	16	41	3	3
253–280	96	100	98	100	93	100	98	100	0	6	0	6	10	39	14	38	3	3
281–308	100	100	98	100	94	100	98	100	0	3	0	13	15	30	17	43	3	3
309–336	98	100	98	100	94	100	98	100	1	0	2	8	16	33	17	46	4	4
337–364	98	100	98	100	97	100	98	100	2	8	2	12	17	24	18	42	4	4
365–392	100	100	100	100	100	100	100	100	0	8	0	6	12	33	23	39	0	0
393–420	100	—	100	—	100	—	100	—	0	—	0	—	0	—	0	—	—	—
421–448	—	100	100	—	—	100	100	—	—	0	0	—	—	0	0	—	—	—
449–476	100	—	—	—	100	—	—	—	0	—	—	—	0	—	—	—	—	—
505–532	100	—	—	—	100	—	—	—	0	—	—	—	100	—	—	—	—	—
617–644	—	—	—	100	—	—	—	100	—	—	—	0	—	—	—	100	0	0
645–672	—	100	—	—	—	100	—	—	—	0	—	—	—	0	—	—	—	—
673–700	100	100	—	—	100	100	—	—	0	0	—	—	0	0	—	—	—	—
701–728	100	100	100	100	100	100	100	100	0	0	0	0	44	50	60	50	0	0
729–756	100	100	100	100	88	100	100	100	0	0	11	25	19	50	33	50	0	0
757–784	100	—	100	100	100	—	100	100	33	—	0	0	33	—	100	50	0	0
785–812	100	—	100	100	100	—	100	100	0	—	0	0	0	—	50	100	0	0
813–840	100	—	100	—	100	—	100	—	25	—	0	—	25	—	33	—	—	—
841–868	100	100	100	—	100	100	100	—	0	0	20	—	67	100	80	—	—	—
869–896	100	100	100	100	100	100	100	100	0	0	0	100	100	0	100	100	0	0
897–924	100	—	100	—	100	—	100	—	33	—	0	—	67	—	100	—	—	—
925–952	100	—	100	—	100	—	100	—	0	—	67	—	0	—	67	—	—	—
981–1008	100	100	—	—	100	100	—	—	0	0	—	—	100	0	—	—	—	—
1009–1036	100	—	—	—	100	—	—	—	0	—	—	—	0	—	—	—	—	—
1205–1232	—	—	100	—	—	—	100	—	—	—	0	—	—	—	0	—	—	—

TABLE V

MEAN TOTAL CARPAL AREAS FOR MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age, days	Male				Female			
	Total Carpal Area		Per Cent of Wrist Size		Total Carpal Area		Per Cent of Wrist Size	
	White	Negro	White	Negro	White	Negro	White	Negro
	sq. mm.	sq. mm.			sq. mm.	sq. mm.		
1–14	0.0	0.0	0.00	0.00	—	0.0	—	0.00
15–28	1.4	1.5	0.36	0.41	4.6	2.5	1.35	0.68
29–56	1.9	4.1	0.46	0.79	3.0	7.9	0.68	2.13
57–84	5.9	6.7	1.23	1.51	9.5	11.7	2.34	3.01
85–112	11.3	11.8	2.38	2.76	16.5	21.5	3.66	5.11
113–140	15.3	21.8	2.80	3.87	19.0	26.2	3.89	5.38
141–168	18.7	25.0	3.42	4.53	24.6	33.9	4.98	6.76
169–196	23.0	30.7	3.92	5.50	26.2	32.6	5.07	6.36
197–224	28.3	34.4	4.63	5.88	29.8	39.5	5.43	7.12
225–252	31.5	36.9	4.90	5.95	33.2	44.9	5.73	7.76
253–280	33.6	44.0	5.07	6.71	36.3	47.3	6.03	7.86
281–308	37.7	45.3	5.52	6.66	40.2	51.8	6.54	8.25
309–336	40.3	48.2	5.70	7.04	42.8	56.8	6.77	8.86
337–364	44.2	51.2	6.07	7.04	46.8	59.4	7.12	8.86
365–392	40.8	54.0	5.57	7.34	48.1	60.1	7.46	9.32
393–420	42.2	—	6.34	—	63.0	—	8.84	—
421–448	—	39.5	—	5.88	38.3	—	6.48	—
449–476	46.0	—	5.99	—	—	—	—	—
505–532	87.0	—	10.51	—	—	—	—	—
617–644	—	—	—	—	—	105.3	—	13.18
645–672	—	59.4	—	7.60	—	—	—	—
673–700	65.3	75.9	7.81	9.58	—	—	—	—
701–728	67.3	86.6	7.87	10.30	78.6	84.7	9.47	10.91
729–756	64.5	84.5	7.64	11.16	81.2	85.4	10.77	10.72
757–784	85.3	—	7.08	—	94.8	78.4	11.45	11.48
785–812	82.7	—	9.36	—	99.1	127.5	11.12	17.56
813–840	104.2	—	8.79	—	79.8	—	9.56	—
841–868	90.0	79.0	10.63	8.81	102.9	—	13.94	—
869–896	113.8	76.8	11.37	8.60	99.5	124.4	10.69	17.34
897–924	95.7	—	10.46	—	110.8	—	12.41	—
925–952	95.2	—	10.22	—	105.6	—	12.62	—
981–1008	144.6	90.0	14.83	10.03	—	—	—	—
1009–1036	128.2	—	13.35	—	—	—	—	—
1205–1232	—	—	—	—	104.2	—	12.46	—

roentgenograms of a child are included only once in any one age group. If two roentgenograms were taken within any one age period the measurements were averaged.

The greater multangular and the navicular were measured when found on the roentgenograms but these bones were present in only a small number of the negro female infants (Table IV).

Capitate. The relative standing of each of the four race and age groups in the size of the capitate was variable from the youngest ages up to the 113–140 day age group (Table III). Among the older infants the

Fig. 3. Diagram showing areas used in measurements of wrist size. Line *AB* is measured from the outermost tip of proximal end of the first metacarpal to the outermost tip of the proximal end of the fourth metacarpal. Line *BC* is from the outermost tip of the proximal end of the fourth metacarpal to the outermost distal end of the ulna. Line *CD* is from the outermost distal end of the ulna to the most exterior tip of the distal end of the radius. Line *AD* is from the most exterior point on the distal end of the radius to the most exterior point of the proximal end of the first metacarpal. Line *EF* is from the midpoint of the proximal end of the third metacarpal to the midpoint of the distal end of the radius.

white males had the smallest capitate, the white females ranked next, followed by the negro males. The negro females had the largest capitate at all ages.

From Table IV it is evident that the capitate appeared in a greater percentage of negro infants in an age group than in the white infants of the same sex and corresponding age. In all groups the values for both white and negro females are higher than the comparable values for either white or negro males. In the negro infants the capitate was present in 100 per cent of the subjects at earlier ages than in the white groups.

Hamate. Except in the groups at 57–84, 85–112 and 141–168 days of age, when the area of the hamate bone was larger for the white female group than for the negro male, the area of the hamate was greatest for the negro females, with the negro males ranking next, the white females third and the white males having the smallest area (Table III). In percentage occurrence the four groups (Table IV) ranked in the same order.

Lunate. The lunate was not present at ages less than 169 days (Table IV). Its area was consistently greater for the negro females than for any of the other groups, which showed no consistent differences (Table III).

Triangular. The triangular was largest for the negro female group at every age level (Table III). The white male group had the smallest average area of the triangular. There was no consistent difference between the negro male and the white female groups except from 253–392 days when the average area of the triangular was larger for the negro male group. The triangular was present in the greatest percentage of the negro female group at every age level but one (Table IV). The white male group showed the lowest percentage having the triangular present.

Total Carpal Area. Of the infants studied during the first year of life, the negro female group had the largest average total carpal area at all age levels from 29 to 392 days and the white males the smallest area (Table V). The average carpal area was greater for negro males than for white females at every age level except 15–28, 57–84 and 85–112 days, when the reverse is true.

Four methods of determining wrist size were tested, using the measurements shown in Figure 3.

1. Considering the wrist size as the sum of the two triangles *ABC* and *ACD*, the areas of which may be obtained by the formula $\sqrt{S(S-x)\ (S-y)\ (S-z)}$, where S = one-half of the perimeter and x, y, and z are the three sides.
2. The average width multiplied by the average length:

$$\frac{AB+DC}{2} \times \frac{BC+AD}{2}.$$

3. Treating the diagonals as altitudes of the two triangles and using the formula for the area of a triangle as one-half the base times the altitude: $\frac{1}{2}(AC)(DB)$
4. Using the formula given by Baldwin, Busby and Garside:[7] $AB \times EF$.

A roentgenogram of the hand and arm of each of twenty children was selected at random and measured as shown in Figure 3. The first calculation is the most exact, but required six measurements, and extensive calculation. To use this method with hundreds of roentgenograms would require a tremendous expenditure of time. However, with the random sample of twenty roentgenograms the area so determined was accepted as a standard for other calculations. The four methods of determining wrist size gave mean values ($\pm$standard error of the mean) of 508.3 ± 28.0, 532.4 ± 28.8, 502.3 ± 27.4 and 544.8 ± 30.2 sq. mm., respectively. These figures indicate the third measurement to be the best substitute for method 1, but to further justify its acceptance, the Analysis of Variance method was applied to the data. Significant differences were found between the standard and the second and fourth determinations, but not between the standard and the third measurement. The data on wrist size presented in this paper were obtained by method 3.

The per cent of wrist size ossified, as measured by the total carpal area per unit of wrist area, was greatest for the negro females, and least for the white males. The negro males and white females were not consistent in relative standing for the various age levels.

MEASUREMENTS OF THE RADIUS AND TIBIA

The lengths of the radius and tibia, and the widths of the distal epiphysis of the radius, the distal ends of the tibia and radius and of the tibia at a point one-third of its length from the distal end were measured (Fig. 4). The mean lengths and widths of the radius and tibia and the mean widths of the distal epiphysis of the radius are given according to sex, race and age group in Table VI. The widths of the radius and tibia at their metaphyses and of the diaphysis of the tibia at a point one-third its length above the distal end were smallest for white female children, followed by negro female children, then the white male infants. The negro male had the greatest dimensions at most age levels. The lengths of the radius and of the tibia were least for

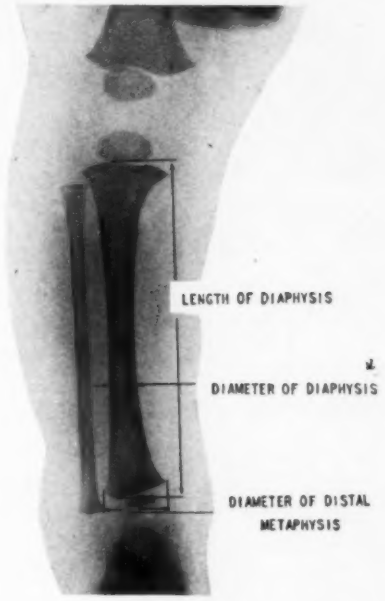

FIG. 4. Roentgenogram of left tibia. Dimensions measured on roentgenograms of tibia for determining status of skeletal development.

the white female group, than either the white males or the negro females and largest for negro male infants. The white male group had the smallest average width of the epiphysis of the radius, the negro males ranked next, then the white females, with the negro female group having epiphyses of the greatest average width.

AGE OF APPEARANCE OF OTHER CENTERS

Tables VII and VIII give the percentages of infants of each sex and race for whom were found centers of the arm such as epiphyses of the metacarpals, phalanges, humerus, radius and ulna. Tables IX and X give the percentages of infants of each sex and race for whom were found centers of

Table VI

Mean dimensions of the radius and tibia of male and female white and negro infants

Values in millimeters

Age, days	Radius												Tibia											
	Length				Width—Metaphyses				Width—Epiphyses				Length				Width—Diaphyses				Width—Metaphyses			
	Male		Female		Male		Female		Male		Female		Male		Female		Male		Female		Male		Female	
	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro	White	Negro
1–14	60.0	57.5	—	55.0	10.7	10.5	—	8.0	0	0	—	0	72.0	70.8	—	67.0	7.2	7.0	—	6.0	13.7	13.0	—	11.5
15–28	57.4	57.9	55.7	57.5	10.8	10.3	10.4	10.0	0	0	0	0	69.8	70.9	70.6	71.5	7.2	7.1	7.2	6.8	13.8	13.4	13.9	13.3
29–56	59.0	61.7	57.3	58.8	11.3	11.3	10.6	10.9	0	0	0	0	73.9	77.3	73.2	74.5	7.4	7.4	7.2	7.2	14.5	14.4	13.9	13.8
57–84	62.0	64.9	59.9	62.9	11.9	12.4	11.3	11.5	0	0	0	0	78.4	81.8	77.4	80.7	7.7	8.2	7.8	8.2	15.0	15.6	14.7	14.9
85–112	63.5	64.8	62.6	65.0	12.3	12.4	12.3	11.8	0	0	0	0	82.4	84.2	82.3	86.3	8.2	8.2	8.0	8.0	15.8	16.2	15.7	15.8
113–140	67.3	69.4	64.6	67.7	13.5	13.6	12.4	13.1	0	0	0	0.2	88.2	91.1	87.1	91.7	8.8	9.3	8.2	8.6	17.2	16.9	16.1	16.8
141–168	69.3	72.4	66.1	69.7	13.8	13.8	12.7	13.1	0	0	0.3	0	92.5	96.9	91.2	95.3	9.0	9.3	8.6	8.6	18.0	18.6	17.0	17.3
169–196	72.1	74.8	68.8	72.1	14.3	14.3	13.2	13.6	0.1	0.3	0.3	0.8	97.1	100.7	95.5	99.5	9.2	9.6	8.7	9.2	18.4	18.8	17.5	17.9
197–224	73.7	77.0	69.9	73.6	14.5	14.5	13.4	14.2	0.4	0.7	0.4	1.4	97.7	104.5	97.1	101.6	9.3	9.7	9.0	9.2	18.9	19.2	17.8	18.5
225–252	76.2	79.0	72.0	77.2	14.8	14.7	13.8	14.4	0.4	0.8	1.2	1.8	103.2	107.3	100.4	106.3	9.5	9.8	9.1	9.6	19.2	19.1	18.4	18.7
253–280	78.0	81.8	74.5	79.0	15.1	15.3	14.2	14.5	1.0	1.8	1.8	2.5	106.1	110.5	104.6	109.3	9.7	10.4	9.3	9.7	19.6	19.8	18.6	19.1
281–308	79.8	83.3	75.9	81.2	15.5	15.4	14.5	14.8	1.0	1.6	2.0	2.5	108.7	113.5	107.0	112.7	9.9	10.2	9.4	10.2	20.2	19.8	18.9	19.5
309–336	81.6	85.7	77.2	81.8	15.6	15.5	14.7	14.6	1.5	1.9	3.1	3.0	111.3	116.8	108.8	115.2	10.1	10.3	9.7	10.3	20.7	20.2	19.5	20.3
337–364	83.4	87.8	79.3	84.6	15.9	16.4	15.0	15.5	2.1	2.5	3.6	4.7	114.1	120.2	112.5	118.7	10.6	10.8	10.1	10.5	21.4	21.1	20.3	21.2
365–392	84.4	88.8	79.9	83.7	16.2	16.5	15.1	15.3	1.7	2.4	3.4	3.6	116.7	122.2	114.4	118.7	11.0	11.3	10.5	10.6	21.7	22.0	21.2	20.8
393–420	84.2	—	80.7	—	16.7	—	16.3	—	2.0	—	4.8	—	118.7	—	117.8	—	10.7	—	11.5	—	22.3	—	22.3	—
421–448	—	88.0	79.2	—	—	15.8	15.5	—	—	0	2.5	—	—	125.5	111.8	—	—	11.0	10.0	—	—	22.5	19.0	—
449–476	88.0	—	—	—	17.3	—	—	—	5.5	—	—	—	124.5	—	—	—	11.0	—	—	—	23.2	—	—	—
505–532	85.0	—	—	—	17.0	—	—	—	0.0	—	—	—	121.5	—	—	—	11.5	—	—	—	24.0	—	—	—
617–644	—	—	—	99.5	—	—	—	17.0	—	—	—	12.0	—	—	—	142.0	—	—	—	13.5	—	—	—	26.0
645–672	—	103.0	—	—	—	17.0	—	—	—	6.0	—	—	—	149.5	—	—	—	12.5	—	—	—	26.5	—	—
673–700	95.0	106.0	—	—	17.5	17.0	—	—	4.5	5.5	—	—	142.0	159.5	—	—	11.5	13.5	—	—	26.0	26.0	—	—
701–728	96.2	101.5	90.6	105.8	16.7	17.2	15.9	16.5	6.0	5.5	7.0	9.2	136.2	147.0	135.9	159.0	11.8	13.0	11.8	13.0	24.7	26.0	25.3	26.0
729–756	99.6	101.5	95.6	103.9	17.2	17.0	16.4	16.2	6.6	8.5	7.5	9.9	143.3	150.0	141.4	154.9	12.2	12.5	12.3	12.9	25.5	24.0	24.5	26.1
757–784	104.2	—	106.0	97.8	18.3	—	17.0	14.5	7.7	—	7.0	7.0	149.7	—	158.5	147.0	13.7	—	13.0	11.5	26.7	—	28.0	22.8
785–812	102.5	—	100.0	105.0	17.8	—	16.8	16.0	4.0	—	12.5	8.0	146.8	—	152.5	159.0	13.0	—	13.0	13.5	26.2	—	26.2	27.0
813–840	101.6	—	95.3	—	17.5	—	16.3	—	8.5	—	9.2	—	148.9	—	144.2	—	13.1	—	12.0	—	26.6	—	25.0	—
841–868	100.3	106.0	98.4	—	17.3	19.0	16.8	—	7.7	11.0	9.1	—	146.2	157.5	145.7	—	12.0	12.5	12.5	—	25.5	26.0	24.9	—
869–896	111.5	109.5	100.5	105.5	18.4	19.0	18.0	16.0	13.0	6.0	9.5	11.0	160.4	165.0	158.5	158.5	14.5	14.0	15.0	12.5	27.8	27.5	28.0	25.5
897–924	102.0	—	106.0	—	17.3	—	17.0	—	8.0	—	10.0	—	150.8	—	159.5	—	13.2	—	14.0	—	25.8	—	26.0	—
925–952	115.5	—	98.2	—	18.0	—	17.2	—	8.5	—	11.5	—	165.8	—	145.8	—	13.0	—	13.7	—	27.5	—	25.7	—
981–1008	101.5	108.5	—	—	18.0	17.0	—	—	8.0	10.0	—	—	149.5	159.0	—	—	12.5	13.0	—	—	28.0	26.0	—	—
1009–1036	122.0	—	—	—	18.0	—	—	—	13.0	—	—	—	179.0	—	—	—	13.0	—	—	—	29.0	—	—	—
1205–1232	—	—	111.5	—	—	—	15.5	—	—	—	9.0	—	—	—	166.5	—	—	—	12.0	—	—	—	25.0	—

the leg such as the tarsals and epiphyses of the metatarsals, proximal phalanges, femur, tibia and fibula. As the calcaneum and astragalus were present in all instances, they were omitted from the table. The distal epiphysis of the femur was present in almost all of the infants. The scaphoid was first observed in the 197–224 day groups of white female and negro male infants. The cuboid was present in some of the earliest roentgenograms examined, but was not present for every infant until 57–84 days for the groups of negro infants, male and female, and 85–112 days for the group of white female infants. In the white male infants it was not until the group was 337–364 days old that there was 100 per cent presence. The distal epiphysis of the femur was present in the first roentgenogram of all the white males and the negro females but was not present in the 15–28 day level of negro males.

Ossification of a center ordinarily originates at a single point, then proceeds radially. However, ossification may start at more than one point within a center, each area developing simultaneously. The frequency of occurrence of such "multiple centers" was determined for each of the four sex and race groups but a consistent difference was not found among the groups. The proximal epiphysis of the radius was not present in any case for white males and females and negro females, nor was the proximal epiphysis of the fibula present in any of the negroes or white females during the first year of life. The distal epiphysis of the ulna was not present in any female nor was the distal epiphysis of the ulna present in any negro male. With only a very few exceptions the centers of the negroes appeared before those of the white race of the same sex.

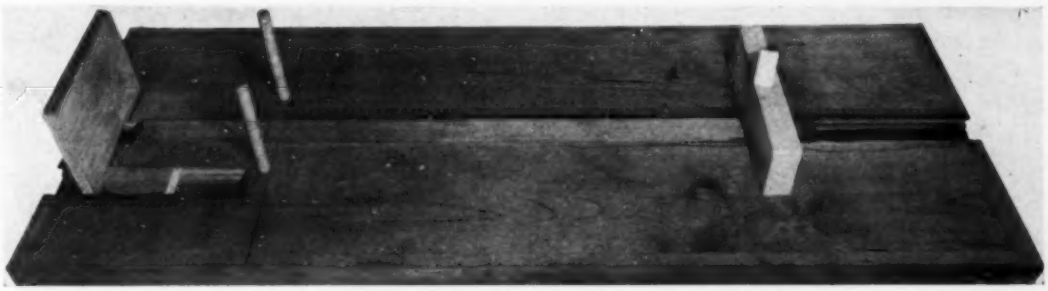

Fig. 5. Measuring board. The base which is placed against the buttocks to measure stem length lifts off of the wedge-shaped piece used to determine trunk length.

Anthropometric Measurements*

Recumbent total body, stem, trunk and head lengths were obtained with the measuring board shown in Figure 5, with the vertical axis of the body parallel to the side of the board and the posts on the board separating the head and trunk. The recumbent total length was determined by pressing the movable base and head boards firmly against the soles of the feet and top

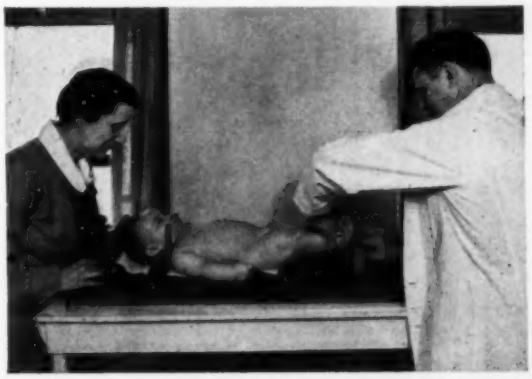

Fig. 6. Determining total recumbent length on the measuring board.

* Anthropometric measurements were taken by Marsh W. Poole, M.D., and Brenton M. Hamil, M.D.

of the head, with the body held flat upon the board (Fig. 6). Stem lengths were taken by raising the legs, knees together and slightly flexed, and moving the base board so that it pressed firmly against the buttocks. The head and trunk were measured with the child in the same position with legs relaxed, using the narrow wedge-shaped post without the perpendicular base board so that the measurement could be taken as near the end of the spine as possible and would exclude the gluteal muscles (Fig. 5). The recumbent trunk and head lengths were obtained separately as the distances from the wooden posts on either side of the neck. The recumbent head length is frequently measured as head height.

Other length measurements and the width and depth measurements were taken with an anthropometer. The head length is the maximum diameter from the glabella, or in some cases the most prominent point just above the glabella, to the most prominent point of the occiput, so that the greatest diameter was obtained. The head width is the maximum diameter taken above the mastoid and zygomatic processes (Fig. 7). Chest width also was taken with the child in the recumbent position. The arms of the

TABLE VII

PRESENCE OF EPIPHYSEAL CENTERS IN MALE WHITE AND NEGRO INFANTS

Per cent in age groups

Age, days	Metacarpals										Phalanges—Hand, Proximal									
	First		Second		Third		Fourth		Fifth		First		Second		Third		Fourth		Fifth	
	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N
1–14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15–28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29–56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57–84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85–112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113–140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0
141–168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	6	0	0
169–196	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	5	0	2	0	0
197–224	0	0	0	0	0	0	0	0	0	0	0	0	1	3	2	9	0	9	0	0
225–252	0	0	0	0	0	0	0	0	0	0	0	0	4	5	4	8	2	8	0	0
253–280	0	0	0	6	0	10	0	0	0	0	0	0	3	13	6	13	3	16	0	0
281–308	0	0	1	7	0	10	0	0	0	3	0	0	8	13	14	17	8	13	1	0
309–336	0	0	2	15	2	15	0	7	0	4	0	0	11	15	12	26	8	15	0	4
337–364	0	4	4	20	4	20	1	8	0	8	0	0	17	24	18	24	13	12	1	4
365–392	0	0	3	17	3	17	3	17	0	8	0	0	24	42	26	42	18	25	6	0
393–420	0	—	0	—	0	—	0	—	0	—	0	—	60	—	60	—	40	—	0	—
421–448	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
449–476	0	—	0	—	0	—	0	—	0	—	0	—	33	—	33	—	0	—	0	—
505–532	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—
645–672	—	0	—	0	—	0	—	0	—	0	—	0	—	100	—	100	—	100	—	100
673–700	0	0	50	100	50	0	50	0	50	0	0	0	50	100	100	100	100	100	50	0
701–728	0	0	67	50	56	50	11	0	11	0	0	0	78	50	78	50	78	50	44	0
729–756	6	0	69	100	56	100	50	100	31	100	0	0	88	100	81	100	81	100	56	50
757–784	0	—	67	—	67	—	67	—	33	—	0	—	100	—	100	—	100	—	100	—
785–812	0	—	50	—	50	—	50	—	50	—	0	—	50	—	100	—	50	—	50	—
813–840	25	—	100	—	100	—	75	—	25	—	0	—	100	—	100	—	100	—	50	—
841–868	33	100	33	100	33	100	33	100	33	100	33	100	67	100	100	100	67	100	33	100
869–896	50	0	100	100	100	100	100	100	75	100	50	100	100	100	100	100	100	100	100	100
897–924	67	—	100	—	100	—	100	—	100	—	0	—	100	—	100	—	100	—	67	—
925–952	50	—	100	—	50	—	50	—	50	—	50	—	100	—	100	—	100	—	50	—
981–1008	0	0	100	100	100	100	100	100	0	100	0	100	100	100	100	100	100	100	0	100
1009–1036	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—

* Not present for any of the white infants.

Fig. 7. Measuring head width with the anthropometer.

Table VII—*Continued*

Phalanges—Hand																		Humerus		Radius			Ulna	
Middle								Distal										Capitellum		Proximal*	Distal		Distal	
Second		Third		Fourth		Fifth		First		Second		Third		Fourth		Fifth								
W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	N	W	N	W	N
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	10	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	9	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39	36	0	0	0	0	0
0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	46	40	0	0	0	0	0
0	0	0	0	0	0	0	0	1	5	0	0	0	2	0	2	0	0	72	67	0	4	10	0	0
0	0	0	3	0	0	0	0	0	9	0	0	0	3	0	3	0	0	81	77	0	10	19	0	0
0	2	0	2	0	2	0	0	2	18	0	2	1	2	0	2	0	2	85	76	0	12	20	0	0
0	3	0	3	0	3	0	3	4	26	0	3	1	6	0	6	0	3	90	84	0	25	32	0	0
0	0	1	7	0	7	0	0	10	23	0	0	1	7	0	7	0	0	91	83	0	32	30	0	0
0	4	1	7	0	7	0	0	15	22	0	4	1	7	1	7	0	0	94	85	0	37	37	0	0
0	4	1	4	1	8	0	0	14	24	0	4	1	8	1	8	0	0	94	88	4	43	36	1	0
9	0	12	8	9	8	0	0	20	33	0	0	9	8	6	8	0	0	88	92	0	32	33	0	0
0	—	0	—	0	—	0	—	40	—	0	—	0	—	0	—	0	—	100	—	—	40	—	0	—
—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	100	0	—	0	—	0
0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	100	—	—	67	—	0	—
0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	100	—	—	0	—	100	—
—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	0	—	0	0	—	100	—	0
50	0	50	0	50	100	0	0	50	100	0	0	0	0	0	100	0	0	100	100	0	50	100	0	0
22	0	33	0	33	0	0	0	44	50	0	0	22	0	22	0	0	0	100	100	0	78	100	0	0
12	50	38	100	38	100	6	0	56	50	0	0	19	50	12	50	0	50	100	100	0	75	100	0	0
100	—	100	—	100	—	0	—	100	—	0	—	67	—	67	—	0	—	100	—	—	100	—	0	—
50	—	50	—	50	—	0	—	100	—	0	—	50	—	50	—	0	—	100	—	—	50	—	50	—
0	—	25	—	25	—	0	—	75	—	25	—	50	—	50	—	25	—	100	—	—	100	—	0	—
33	100	33	100	33	100	33	100	33	100	33	0	33	100	33	100	33	100	100	100	0	100	100	0	100
75	100	100	100	100	100	25	100	75	100	50	100	75	100	75	100	50	100	100	100	0	100	100	25	0
100	—	100	—	100	—	33	—	67	—	33	—	100	—	100	—	33	—	100	—	—	100	—	0	—
50	—	50	—	50	—	0	—	100	—	0	—	50	—	50	—	0	—	100	—	—	100	—	0	—
0	100	0	100	0	100	0	0	100	100	0	0	0	100	0	100	0	0	100	100	0	100	100	100	0
100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	—	100	—	0	—

anthropometer were kept in the same transverse plane as the nipples and moderate pressure was used to obtain a reading between that of inspiration and expiration. The chest depth was measured with the child recumbent but on his side. The movable arm of the anthropometer was held even with the nipples and the fixed arm placed just below the inferior angles of the scapulae. The intercristal width was measured between the outermost anterior points of the iliac crests. The arms of the anthropometer were placed to avoid the iliac "fat pads" and pressure was applied so that the dimension would represent little more than the distance between the outer edges of the bones.

The tibial length was taken when the subject was recumbent upon the measuring table, his left knee held flexed with the thigh abducted and laterally rotated. This caused the proximal margin of the medial condyle of the tibia to stand out prominently in most individuals. The measurement was made from the proximal margin of the medial condyle of the tibia to the distal border of the medial malleolus. Girths were measured with a steel tape with a constant tension "Güllick" spring handle. The chest girth was taken at the level of the nipples and the inferior angles of the scapulae. In measuring the head circumference the glabella, or in some cases the most prominent part of the forehead and the most prominent point of the occiput were used as landmarks (Fig. 8) to obtain the

TABLE VIII

PRESENCE OF EPIPHYSEAL CENTERS IN FEMALE WHITE AND NEGRO INFANTS

Per cent occurrence in age groups

Age, days	Metacarpals										Phalanges—Hand									
											Proximal									
	First		Second		Third		Fourth		Fifth		First		Second		Third		Fourth		Fifth	
	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N
1–14	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
15–28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29–56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57–84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85–112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
113–140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141–168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	0	6	0	0
169–196	0	0	0	2	0	2	0	0	0	0	0	0	1	4	4	11	2	11	0	0
197–224	0	0	2	7	2	3	0	0	0	0	0	0	7	7	7	27	7	13	0	3
225–252	0	0	2	10	2	14	0	10	0	3	0	0	14	21	19	28	16	21	0	7
253–280	1	0	4	18	4	15	1	15	0	9	0	0	26	32	32	38	19	29	0	15
281–308	3	7	8	37	8	30	3	20	0	10	0	7	36	60	37	50	24	43	8	13
309–336	5	0	13	42	10	31	8	19	7	8	2	4	50	62	52	65	45	54	8	15
337–364	8	15	26	54	22	46	11	35	10	19	2	15	66	73	72	77	63	65	18	31
365–392	4	6	38	44	27	44	15	39	15	28	0	0	69	78	69	78	62	78	23	50
393–420	0	—	33	—	33	—	33	—	33	—	0	—	100	—	100	—	33	—	0	—
421–448	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—
617–644	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100
701–728	80	100	100	100	100	100	100	100	100	100	80	100	100	100	100	100	100	100	100	100
729–756	78	100	100	100	100	100	89	100	67	100	56	100	100	100	100	100	100	100	100	100
757–784	100	50	100	100	100	100	100	100	100	100	100	50	100	100	100	100	100	100	100	100
785–812	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
813–840	67	—	100	—	67	—	67	—	33	—	67	—	100	—	100	—	100	—	100	—
841–868	80	—	100	—	100	—	100	—	100	—	40	—	100	—	100	—	100	—	100	—
869–896	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
897–924	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—
925–952	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—
1205–1232	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—

* Not present for any of the negro infants.

† Not present for any of the white infants.

Fig. 8. Measuring head circumference with steel tape with constant tension handle.

Table VIII—*Continued*

Phalanges—Hand																Humerus		Radius			Ulna
Middle								Distal								Capitellum		Proximal*	Distal		Distal†
Second		Third		Fourth		Fifth		First		Second		Third		Fourth		Fifth					
W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	W	N	N
—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	—	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2	12	0	0	0	0	0	0	0	0	0	0	0	0
0	2	0	8	0	9	0	0	1	9	0	0	0	2	0	2	0	0	0	0	0	0
0	7	0	10	2	13	0	3	7	17	0	3	0	7	0	7	0	0	0	0	0	0
0	7	2	17	3	14	0	3	9	21	0	3	0	7	0	10	0	3	0	0	0	0
1	15	3	29	3	26	0	9	14	29	0	3	1	15	0	15	0	6	0	0	0	0
3	20	10	30	8	30	0	10	27	47	0	10	3	13	0	17	0	7	0	0	0	0
10	27	13	31	18	35	2	8	38	58	0	8	5	27	2	15	0	12	0	0	0	0
16	27	29	38	27	38	5	12	52	62	0	12	6	27	3	27	0	12	0	0	0	0
27	50	35	56	38	56	0	11	50	72	0	17	8	44	4	33	4	11	0	0	0	0
0	—	33	—	33	—	0	—	67	—	0	—	0	—	0	—	0	—	0	0	0	0
0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0	0	0	0
—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	—	100	0
100	100	100	100	100	100	80	100	100	100	80	100	100	100	100	100	80	100	100	0	100	50
100	100	100	100	100	100	67	50	100	100	33	100	89	100	89	100	44	75	100	0	100	0
100	100	100	100	100	100	100	50	100	100	100	50	100	100	100	100	100	50	100	0	100	0
100	100	100	100	100	100	100	0	100	100	100	100	100	100	100	100	100	0	100	50	100	0
100	—	100	—	100	—	33	—	100	—	33	—	67	—	67	—	33	—	100	0	100	—
100	—	100	—	100	—	40	—	100	—	60	—	100	—	100	—	60	—	100	0	100	—
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	100	0
100	—	100	—	100	—	0	—	100	—	100	—	100	—	100	—	100	—	100	0	100	—
100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	0	100	—
100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	0	100	—

TABLE IX

PRESENCE OF EPIPHYSEAL CENTERS IN MALE WHITE AND NEGRO INFANTS
Per cent occurrence in age groups

Age, days	Tarsals*										Metatarsals†					
	Scaphoid		Cuboid		Cuneiform						First		Second‡	Third‡	Fourth‡	
					External		Middle		Internal							
	W	N	W	N	W	N	W	N	W	N	W	N	W	W	W	
1–14	0	0	33	50	0	0	0	0	0	0	0	0	0	0	0	
15–28	0	0	51	77	7	15	0	0	0	0	0	0	0	0	0	
29–56	0	0	78	87	9	33	0	0	0	0	0	0	0	0	0	
57–84	0	0	92	100	27	65	0	0	0	0	0	0	0	0	0	
85–112	0	0	94	100	35	83	0	0	0	0	0	0	0	0	0	
113–140	0	0	98	100	56	93	0	0	0	0	0	0	0	0	0	
141–168	0	0	97	100	68	94	0	0	0	0	0	0	0	0	0	
169–196	0	0	98	100	72	93	0	0	1	0	0	0	0	0	0	
197–224	0	3	100	100	81	94	0	0	0	9	0	0	0	0	0	
225–252	0	0	100	100	84	92	0	5	0	10	0	0	0	0	0	
253–280	0	3	99	100	84	90	0	6	0	19	0	0	0	0	0	
281–308	0	3	100	100	89	90	0	3	0	17	0	0	0	0	0	
309–336	0	0	99	100	88	89	0	7	2	22	0	0	0	0	0	
337–364	1	4	100	100	90	88	1	4	3	24	0	0	0	0	0	
365–392	3	0	100	100	85	92	6	17	9	17	0	0	0	0	0	
393–420	0	—	100	—	100	—	0	—	20	—	0	—	0	0	0	
421–448	—	0	—	100	—	100	—	0	—	0	—	0	—	—	—	
449–476	0	—	100	—	100	—	0	—	0	—	0	—	0	0	0	
505–532	0	—	100	—	100	—	0	—	100	—	0	—	0	0	0	
645–672	—	0	—	100	—	100	—	0	—	0	—	100	—	—	—	
673–700	50	0	100	100	100	100	0	0	50	100	0	100	0	0	0	
701–728	0	0	100	100	100	100	0	0	22	50	0	0	0	0	0	
729–756	6	0	100	100	94	100	12	50	25	100	19	50	0	0	0	
757–784	33	—	100	—	100	—	33	—	33	—	67	—	0	0	0	
785–812	0	—	100	—	100	—	50	—	50	—	0	—	0	0	0	
813–840	25	—	100	—	100	—	25	—	50	—	25	—	25	25	0	
841–868	67	0	100	100	100	100	67	0	67	0	33	100	0	0	0	
869–896	50	0	100	100	100	100	50	0	75	0	50	0	25	25	25	
897–924	33	—	100	—	100	—	33	—	67	—	67	—	0	0	0	
925–952	50	—	100	—	100	—	50	—	50	—	50	—	0	0	0	
981–1008	100	0	100	100	100	100	100	0	100	0	100	100	0	0	0	
1009–1036	0	—	100	—	100	—	0	—	0	—	100	—	100	100	0	

* Calcaneum and astragulus present in all subjects.
† The fifth metatarsal was not present in any subject.
‡ Not present in negro subjects.

greatest circumference. The abdominal circumference was taken at the level of the umbilicus, in a plane perpendicular to the spine. The girth of the upper arm was taken with the arm in extension, at the most prominent point of the biceps. The girth of the thigh was measured in a plane perpendicular to the longitudinal axis of the femur, just below the gluteal fold. The infants were weighed on a Fairbanks beam balance.

Recumbent Body Length, Total (Table XI). The white male babies were longer in every age group than the white female babies and for all but two age groups (in which they were equal) than the negro male babies. The latter, in every age group, were longer than the negro female babies. The negro male infants were longer than the white female infants during the first year, except those in the age groups 15–28 and 29–56 days. The white females were longer than the negro females during the first half of the first year of life. After 140 days of age the white females were shorter than the negro females except in the age group 169–224

TABLE IX—*Continued*

Phalanges—Foot (proximal)										Femur		Tibia				Fibula		
First		Second		Third		Fourth		Fifth		Distal		Proximal		Distal		Proximal‡	Distal	
W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	W	N
0	0	0	0	0	0	0	0	0	0	100	100	100	50	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	100	92	93	69	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	91	97	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	100	90	4	0	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	95	100	5	9	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	100	93	50	31	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	100	100	68	46	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	100	100	75	63	1	1	2
0	0	0	0	0	0	0	0	0	0	100	100	100	100	93	80	0	3	3
0	0	0	0	1	0	0	0	0	0	100	100	100	100	96	78	0	5	10
0	0	1	3	3	3	2	0	0	0	100	100	100	100	100	94	0	18	13
0	0	1	3	5	3	3	3	0	0	100	100	100	100	100	90	0	26	15
0	0	3	4	7	4	6	4	0	0	100	100	100	100	100	89	0	32	21
0	0	3	4	9	4	4	4	0	0	100	100	100	100	100	92	0	40	26
0	0	9	0	18	8	12	0	0	0	100	100	100	100	100	92	0	59	67
0	—	0	—	40	—	40	—	0	—	100	—	100	—	100	—	0	20	—
—	0	—	0	—	0	—	0	—	0	—	100	—	100	—	100	—	—	0
0	—	0	—	0	—	0	—	0	—	100	—	100	—	100	—	0	67	—
0	—	0	—	0	—	0	—	0	—	100	—	100	—	100	—	0	0	—
—	0	—	100	—	100	—	100	—	0	—	100	—	100	—	100	—	—	100
0	100	50	100	50	0	50	0	0	0	100	100	100	100	100	100	0	100	100
0	0	56	0	56	0	56	0	0	0	100	100	100	100	100	100	0	89	100
19	50	62	100	69	50	69	50	12	0	100	100	100	100	100	100	0	94	100
0	—	100	—	100	—	100	—	33	—	100	—	100	—	100	—	0	100	—
0	—	50	—	50	—	50	—	0	—	100	—	100	—	100	—	0	100	—
25	—	100	—	75	—	75	—	0	—	100	—	100	—	100	—	0	100	—
33	100	33	100	67	100	67	100	33	100	100	100	100	100	100	100	0	100	100
75	100	100	100	100	100	100	100	75	100	100	100	100	100	100	100	25	100	100
67	—	100	—	100	—	100	—	67	—	100	—	100	—	100	—	0	100	—
50	—	50	—	50	—	50	—	0	—	100	—	100	—	100	—	0	100	—
0	100	100	0	100	0	100	0	0	0	100	100	100	100	100	100	0	100	100
100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	100	—

days, in which they were equal.

The averages given by Simmons[47] for white babies of 3, 6 and 9 months are smaller than the corresponding averages for males and females given in Table XI, although the values in the table fall within Simmons' total range. The values for females 360 days old are approximately equal to those given by Simmons for girls 12 months old.

Recumbent Stem Length (Table XII). In every age group the average stem length was greatest for the white males and smallest for the negro females. In the age groups 15–28 days and 29–56 days the white females were longer than the negro males but for all other age groups of the first year of life the reverse is true.

The average values for white babies all fall within the ranges for corresponding age groups given by Simmons[47] for the first year of life, but vary from her averages.

Recumbent Trunk Length (Table XIII). In every age group the white males had the longest trunks and the negro females had the shortest. In the 15–28 and 29–56 day groups the white females had longer trunks than the negro males but after 57 days the reverse is true except for two age groups when they are equal.

TABLE X

PRESENCE OF EPIPHYSEAL CENTERS IN FEMALE WHITE AND NEGRO INFANTS

Per cent occurrence in age groups

Age, days	Tarsals*										Metatarsals†							
	Scaphoid		Cuboid		Cuneiform						First		Second		Third		Fourth	
					External		Middle		Internal									
	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N
1–14	—	0	—	100	—	0	0	0	—	0	—	0	—	0	—	0	—	0
15–28	0	0	86	72	21	6	0	0	0	0	0	0	0	0	0	0	0	0
29–56	0	0	94	94	25	48	0	0	0	0	0	0	0	0	0	0	0	0
57–84	0	0	98	100	40	50	0	0	0	0	0	0	0	0	0	0	0	0
85–112	0	0	100	100	58	100	0	0	0	0	0	0	0	0	0	0	0	0
113–140	0	0	100	100	57	93	0	0	0	0	0	0	0	0	0	0	0	0
141–168	0	0	100	100	79	94	0	0	0	0	0	0	0	0	0	0	0	0
169–196	0	0	100	100	86	91	1	4	4	2	0	0	0	0	0	0	0	0
197–224	2	0	100	100	82	97	0	7	2	3	0	0	0	0	0	0	0	0
225–252	2	3	100	100	83	96	0	10	7	7	0	0	0	0	0	0	0	0
253–280	1	3	100	100	88	97	3	12	13	6	0	0	0	0	0	0	0	0
281–308	5	7	100	100	93	97	7	10	24	30	0	0	0	0	0	0	0	0
309–336	7	4	100	100	95	92	8	19	28	27	0	0	0	0	0	0	0	0
337–364	10	8	100	100	95	92	13	19	27	27	2	0	0	0	0	0	0	0
365–392	8	0	100	100	92	100	12	0	27	28	0	0	0	0	0	0	0	0
393–420	0	—	100	—	100	—	33	—	33	—	0	—	0	—	0	—	0	—
421–448	0	—	100	—	100	—	0	—	0	—	0	—	0	—	0	—	0	—
617–644	—	0	—	100	—	100	—	0	—	100	—	100	—	0	—	0	—	0
701–728	20	50	100	100	100	100	60	100	80	100	80	100	40	50	0	50	0	0
729–756	44	75	100	100	100	100	56	75	89	75	89	75	11	50	11	0	0	0
757–784	100	0	100	100	100	100	100	50	100	50	100	100	100	50	100	0	100	0
785–812	100	0	100	100	100	100	100	100	100	100	100	100	100	0	50	0	0	0
813–840	33	—	100	—	100	—	100	—	100	—	100	—	33	—	0	—	0	—
841–868	60	—	100	—	100	—	80	—	80	—	80	—	80	—	40	—	20	—
869–896	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	100
897–924	0	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	0	—
925–952	67	—	100	—	100	—	67	—	67	—	100	—	67	—	33	—	33	—
1205–1232	0	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	0	—

* Calcaneum and astragulus present in all subjects.
† The fifth metacarpal was not present in any subject.
‡ Not present in negro subjects.

Recumbent Head Length (Table XIV). In all but two age groups, 113–140 and 309–336 days, when the averages for the recumbent body length of the two male groups are equal the average length of the head is greatest for the white male babies. The heads of the negro male babies were longer than those of the females of either race in all but two age groups. There was no consistent difference between the females of the two races.

Head Width (Table XV). The white males had the widest heads and the negro males the next widest, while the females of the two races showed no consistent difference from 57–392 days. The average for the series indicate wider heads than those of the babies of Simmons'[47] series but they fall within her total range of values.

Head Length (Table XVI). The average head length for the 15–28 days, 29–56 days and 57–84 day age groups was largest for the white male groups. For all age groups above 85 days it was greatest for negro males with the exception of two age groups when the male groups are equal. The negro females had longer heads than did the white females, in all age groups from 57–392 days. The averages for the series of age groups for white females are larger than those of Simmons for corresponding age groups, while there is no consistency for the groups

TABLE X—*Continued*

Phalanges—Foot (proximal)										Femur		Tibia				Fibula		
First		Second		Third		Fourth		Fifth		Distal		Proximal		Distal		Proximal‡	Distal	
W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	W	N
—	0	—	0	—	0	—	0	—	0	—	100	—	100	—	0	—	—	0
0	0	0	0	0	0	0	0	0	0	100	100	90	94	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	96	97	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	100	100	6	5	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	98	100	10	8	0	0	0
0	0	0	0	0	0	0	0	0	0	100	100	100	100	41	14	0	0	0
0	0	0	0	2	0	0	0	0	0	100	100	100	100	74	43	0	2	0
0	0	0	0	2	2	1	0	0	0	100	100	100	100	93	63	0	9	4
0	0	0	0	5	3	2	3	0	0	100	100	100	100	98	83	0	11	8
0	0	3	3	16	7	2	7	0	0	100	100	100	100	98	93	0	36	22
0	3	6	6	22	9	7	6	0	0	100	100	100	100	100	94	0	57	30
0	7	10	10	32	17	22	13	0	0	100	100	100	100	100	100	0	68	52
0	4	12	8	38	15	28	12	2	0	100	100	100	100	100	96	0	75	65
0	8	37	27	56	38	47	31	2	8	100	100	100	100	100	100	0	88	73
0	0	35	39	58	44	54	33	4	0	100	100	100	100	100	100	0	88	78
0	—	33	—	67	—	67	—	0	—	100	—	100	—	100	—	0	100	—
0	—	0	—	0	—	0	—	0	—	100	—	100	—	100	—	0	50	—
—	100	—	100	—	100	—	100	—	0	—	100	—	100	—	100	—	—	100
100	100	100	100	100	100	100	100	80	100	100	100	100	100	100	100	20	100	100
78	100	100	100	100	100	100	100	33	75	100	100	100	100	100	100	11	100	100
100	50	100	100	100	100	100	100	100	0	100	100	100	100	100	100	0	100	100
100	100	100	100	100	100	100	100	100	0	100	100	100	100	100	100	100	100	100
100	—	100	—	100	—	100	—	67	—	100	—	100	—	100	—	0	100	—
80	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	0	100	—
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	100	100
100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	0	100	—
100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	67	100	—
100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	—	100	100	—

of white males. In all cases the averages fall within the total ranges given by Simmons.

The trend during the first year of life appeared in each sex and race group to be from the dolichocephalic to brachycephalic type. The white male babies, on the average, were more brachycephalic than the other groups, with the white females ranking next. The negro female groups were the most dolichocephalic, though they would not be considered dolichocephalic according to the less-than-80 cephalic ratio classification except in the age groups 15–28 days, 29–56 days and 57–84 days. The latter groups would be considered mesaticephalic according to the 77.7–80 cephalic ratio classification.

Head Circumference (Table XVII). The males of both races had larger head circumferences than the females of either race, but there was no consistent difference between the males of the two races. The white females had smaller head circumferences than the negro female babies in most of the age groups.

Chest Width (Table XVIII). The average chest width for all the age groups during the first year was greater for the white male babies than for the negro male babies. The groups of negro males had greater chest widths than did the white female babies except the 15–28 and 29–56 day age groups which were equal. The average chest width of the white female babies was greater than that of the negro female children. In all

TABLE XI

MEAN RECUMBENT TOTAL LENGTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Length	Subjects	Length	Subjects	Length	Subjects	Length
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	54.2	1	50.8	—	—	—	—
15–28	43	53.5	14	51.8	31	53.1	18	51.5
29–56	131	56.2	42	55.1	96	55.2	49	54.2
57–84	166	59.2	51	58.4	124	57.7	60	57.0
85–112	161	61.7	46	61.0	122	60.2	58	59.9
113–140	161	64.1	52	63.7	117	62.5	56	62.2
141–168	160	66.2	52	66.0	106	64.3	55	64.4
169–196	155	68.0	46	67.5	113	65.9	54	65.9
197–224	150	69.4	43	69.2	97	67.5	52	67.5
225–252	142	70.7	46	70.5	93	69.1	48	69.2
253–280	141	72.1	43	72.1	92	70.4	50	70.6
281–308	124	73.6	38	73.2	82	71.6	40	72.1
309–336	121	74.8	33	74.8	81	72.8	33	73.1
337–364	108	76.2	29	76.0	72	74.1	34	74.3
365–392	40	77.1	13	76.8	29	75.1	18	74.8
393–420	7	76.3	2	76.2	4	74.7	—	—
421–448	3	76.3	2	77.8	1	72.0	—	—
449–476	3	77.7	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	84.0
645–672	—	—	1	87.5	—	—	—	—
673–700	1	88.2	1	91.0	—	—	—	—
701–728	8	86.4	2	88.2	4	85.2	2	91.0
729–756	16	87.5	1	90.0	11	88.0	4	89.2
757–784	3	91.0	—	—	1	95.0	2	83.3
785–812	1	76.6	—	—	2	89.1	2	90.4
813–840	4	89.4	—	—	2	84.8	—	—
841–868	3	87.9	1	89.8	6	85.5	—	—
869–896	5	94.2	—	—	1	91.7	1	90.7
897–924	3	91.2	—	—	1	94.4	—	—
925–952	2	97.2	—	—	3	88.1	—	—
981–1008	1	91.6	1	91.3	—	—	—	—
1009–1036	1	100.3	—	—	—	—	—	—
1205–1232	—	—	—	—	1	92.7	—	—

corresponding age groups, Simmons' averages for white infants were smaller than those obtained in the present study but the values given in the table fall within her total range of values.

Chest Depth (Table XIX). The males of both races had consistently larger chest depths than the females but there was no consistent difference between the two races for either sex.

Chest Circumference (Table XX). The white male babies had larger chest circumferences than the negro male babies who, in turn, had larger chest circumferences than the females of either race. There was no consistent racial difference in the chest circumference of the females.

Abdominal Circumference (Table XXI). The male babies consistently had greater abdominal circumferences than the females

TABLE XII

MEAN RECUMBENT STEM LENGTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Length	Subjects	Length	Subjects	Length	Subjects	Length
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	—	—	1	34.8	—	—	—	—
15–28	40	36.1	13	34.8	28	35.6	18	34.2
29–56	124	38.1	42	37.0	90	37.2	45	36.1
57–84	163	40.1	46	39.3	123	38.9	60	38.2
85–112	158	41.8	45	40.7	120	40.6	58	40.0
113–140	161	43.4	52	42.7	117	42.0	56	41.3
141–168	160	44.8	52	43.9	106	43.2	55	42.8
169–196	155	45.8	46	44.7	114	44.4	54	43.6
197–224	150	46.6	43	45.6	97	45.1	52	44.5
225–252	142	47.2	46	46.4	93	45.9	48	45.5
253–280	141	47.9	43	47.2	92	46.6	50	46.1
281–308	124	48.6	38	47.6	81	47.2	40	46.9
309–336	120	49.3	33	48.6	81	47.8	33	47.2
337–364	108	49.8	29	48.8	72	48.3	34	47.6
365–392	40	50.6	13	49.6	29	48.9	18	47.8
393–420	7	50.2	2	48.6	4	48.6	—	—
421–448	3	50.2	2	48.8	1	47.7	—	—
449–476	3	50.5	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	52.3
645–672	—	—	1	52.7	—	—	—	—
673–700	1	54.2	1	54.3	—	—	—	—
701–728	8	54.1	2	55.2	4	53.6	2	54.4
729–756	15	54.3	1	54.7	11	53.9	4	53.7
757–784	3	56.0	—	—	1	56.5	2	49.6
785–812	1	54.6	—	—	2	54.2	2	55.6
813–840	4	55.3	—	—	2	53.4	—	—
841–868	3	54.3	1	54.8	6	53.0	—	—
869–896	5	56.2	—	—	1	56.8	1	54.7
897–924	3	56.0	—	—	1	56.3	—	—
925–952	2	58.4	—	—	3	53.8	—	—
981–1008	1	56.6	1	54.0	—	—	—	—

but there was no consistent difference between the races. During the first year the negro female babies of all but two age groups (when they were equal) had greater abdominal circumferences than the white female babies.

Intercristal Width (Table XXII). The white male babies in every age group from 29 days throughout the first year had the largest intercristal widths. The negro female babies, except at three age groups when the averages were equal to those for the negro males, had the smallest intercristal widths. There was no consistent difference between the age groups of white female and negro male babies. For the white infants of both sexes the average intercristal width was the same at the three month level as those of Simmons. At the nine and twelve month levels the babies in the present study were larger, on the average, but were within Simmons' total range of values. The white male babies were even smaller than Simmons' minimum

TABLE XIII

MEAN RECUMBENT TRUNK LENGTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Length	Subjects	Length	Subjects	Length	Subjects	Length
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	22.6	1	21.0	—	—	—	—
15–28	43	22.1	14	21.4	31	22.0	19	21.3
29–56	131	23.3	42	22.7	96	22.9	49	22.2
57–84	166	24.7	51	24.2	124	23.9	60	23.5
85–112	161	25.9	46	25.2	122	25.1	58	24.5
113–140	161	27.0	52	26.3	117	26.2	56	25.5
141–168	160	27.9	52	27.2	106	26.9	55	26.5
169–196	155	28.6	46	27.7	114	27.7	54	27.2
197–224	150	29.1	43	28.6	97	28.1	52	27.7
225–252	142	29.5	46	28.9	93	28.6	48	28.2
253–280	141	29.9	43	29.4	92	29.1	50	28.6
281–308	124	30.3	38	29.7	82	29.4	40	28.8
309–336	121	30.7	33	30.1	81	29.8	33	29.0
337–364	108	31.0	29	30.1	72	30.1	34	29.4
365–392	40	31.6	13	30.8	29	30.6	18	29.4
393–420	7	31.5	2	30.2	4	31.0	—	—
421–448	3	31.6	2	30.8	1	30.7	—	—
449–476	3	31.9	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	31.9
645–672	—	—	1	33.2	—	—	—	—
673–700	1	34.3	1	34.2	—	—	—	—
701–728	8	33.9	2	36.0	4	33.5	2	34.6
729–756	16	34.1	1	33.7	11	33.5	4	33.4
757–784	3	35.3	—	—	1	35.0	2	30.0
785–812	1	33.9	—	—	2	34.3	2	34.9
813–840	4	33.9	—	—	2	33.2	—	—
841–868	3	32.9	1	33.7	6	32.8	—	—
869–896	5	35.3	—	—	1	35.0	1	33.0
897–924	3	34.4	—	—	1	35.0	—	—
925–952	2	35.9	—	—	3	33.8	—	—
981–1008	1	36.1	1	33.0	—	—	—	—

value at the six month level, while the averages for white female babies are approximately the same.

Upper Arm Girth (Table XXIII). The negro male babies had the greatest upper arm girth and the white female babies the smallest. Although there was no consistent difference between the white males and the negro female babies, the trend was for the negro female to be larger during the first part of the year, 29–140 days, and for the white males to be larger during the last part of the first year of life.

Thigh (Table XXIV). The relative position of the sex and race groups varied so that there was no consistent level from one age group to another in thigh girths.

Tibial Length (Table XXV). The negro male babies had the longest tibial length, the negro female babies ranked next, with the white female babies having the shortest tibia.

TABLE XIV

MEAN RECUMBENT HEAD LENGTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Length	Subjects	Length	Subjects	Length	Subjects	Length
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	13.0	1	13.5	—	—	—	—
15–28	43	13.6	14	12.9	31	13.2	19	12.7
29–56	131	14.2	42	13.8	96	13.7	49	13.5
57–84	166	14.9	51	14.4	124	14.4	60	14.0
85–112	161	15.3	46	15.0	122	14.8	58	14.8
113–140	161	15.7	52	15.7	117	15.1	56	15.2
141–168	160	16.1	52	16.0	106	15.5	55	15.5
169–196	155	16.5	46	16.4	114	15.9	54	15.7
197–224	150	16.7	43	16.4	97	16.2	52	16.2
225–252	142	17.0	46	16.9	93	16.5	48	16.6
253–280	141	17.3	43	17.2	92	16.8	50	16.8
281–308	124	17.6	38	17.2	82	17.0	40	17.1
309–336	121	17.8	33	17.8	81	17.2	33	17.4
337–364	108	18.1	29	17.8	72	17.4	34	17.4
365–392	40	18.4	13	18.1	29	17.5	18	17.7
393–420	7	18.2	2	18.0	4	17.0	—	—
421–448	3	18.0	2	17.8	1	17.0	—	—
449–476	3	18.3	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	19.5
645–672	—	—	1	19.5	—	—	—	—
673–700	1	19.2	1	19.0	—	—	—	—
701–728	2	20.1	2	19 2	4	19.4	2	19.5
729–756	16	19.5	1	20.0	11	19.2	4	19.0
757–784	3	19.9	—	—	1	20.0	2	18.6
785–812	1	19.9	—	—	2	18.8	2	19.8
813–840	4	19.8	—	—	2	19.1	—	—
841–868	3	19.5	1	19.8	6	19.1	—	—
869–896	5	19.9	—	—	1	20.3	1	20.5
897–924	3	20.2	—	—	1	19.8	—	—
925–952	2	20.9	—	—	3	18.9	—	—
981–1008	1	19.3	1	20.0	—	—	—	—

Weight (Table XXVI). The males of both races were heavier at each level than the females. The white males were heavier than the negro males at all but two age levels during the first year. The negro females were heavier than the white female babies from 57 to 224 days, after which there was no consistent difference. The average nude weights for the white babies were less at corresponding age levels than were those of Simmons' study on white children, but the averages fell within the ranges given by Simmons, although her weights were taken with clothes on the babies.

DISCUSSION

Beckman[8] has made similar comparisons in weight and stature of the race and sex group during the adolescent period (12–16 years). He did not find the same relative standing as in our babies. Wolff and Steggerda[52] studied the head of the adult white

TABLE XV

MEAN HEAD WIDTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Width	Subjects	Width	Subjects	Width	Subjects	Width
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	9.6	1	9.5	—	—	—	—
15–28	43	10.0	14	9.9	31	10.0	19	9.8
29–56	132	10.4	43	10.4	96	10.2	50	10.1
57–84	166	10.9	51	10.8	124	10.6	60	10.6
85–112	161	11.4	46	11.2	122	11.0	58	11.0
113–140	162	11.8	52	11.6	118	11.4	56	11.4
141–168	160	12.1	52	11.9	106	11.6	55	11.7
169–196	155	12.4	46	12.2	114	12.0	54	11.9
197–224	150	12.6	43	12.5	97	12.1	52	12.1
225–252	142	12.7	46	12.5	95	12.3	48	12.3
253–280	141	12.9	43	12.7	92	12.4	50	12.4
281–308	124	12.9	38	12.8	82	12.5	40	12.6
309–336	122	13.1	33	12.9	81	12.6	33	12.6
337–364	108	13.2	29	13.0	72	12.7	34	12.6
365–392	40	13.3	13	13.1	29	12.5	18	12.7
393–420	7	13.2	2	12.7	4	13.0	—	—
421–448	3	13.2	2	12.8	1	12.2	—	—
449–476	3	13.3	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	14.0
645–672	—	—	1	13.5	—	—	—	—
673–700	1	13.5	1	13.2	—	—	—	—
701–728	8	13.9	2	13.7	4	13.3	2	13.8
729–756	16	13.4	1	12.8	11	13.3	4	13.6
757–784	3	13.6	—	—	1	13.7	2	12.3
785–812	1	12.6	—	—	2	14.2	2	13.7
813–840	4	13.8	—	—	2	13.8	—	—
841–868	3	13.3	1	14.2	6	13.0	—	—
869–896	5	13.8	—	—	1	13.7	1	13.4
897–924	3	13.7	—	—	1	13.2	—	—
925–952	2	14.8	—	—	3	13.0	—	—
981–1008	1	13.4	1	13.8	—	—	—	—

and negro, comparing the negroes at Tuskegee Institute, Alabama, with a group of middle age Dutch from Holland, Michigan. The relative standing between sexes is the same as for our infants, with the males having larger heads in all respects than the females, but not always between races. We disagree in head width as to the relative ranking of white and negro male infants. Our values show no consistent difference in the series of females, but Wolff and Steggerda found the negro females to have the narrowest head. Relative standing for head length is just the same in that we both found the head of the negro male to be longest, the white males second, and the white females to have the shortest head.

Todd[51] in comparing a group of negro and white, female and male adult cadavers, agreed with the results found in our babies in the racial difference in chest circumfer-

TABLE XVI

MEAN HEAD LENGTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Length	Subjects	Length	Subjects	Length	Subjects	Length
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	12.7	1	11.7	—	—	—	—
15–28	43	12.6	14	12.3	31	12.4	19	12.3
29–56	132	13.2	43	13.0	96	12.9	50	12.9
57–84	166	13.6	51	13.5	124	13.2	60	13.4
85–112	161	13.9	46	13.9	122	13.5	58	13.8
113–140	162	14.2	52	14.3	118	13.8	56	14.1
141–168	160	14.5	52	14.6	106	14.2	55	14.5
169–196	155	14.7	46	14.8	114	14.4	54	14.6
197–224	150	15.0	43	15.1	97	14.7	52	14.9
225–252	142	15.2	46	15.2	95	14.9	47	15.0
253–280	141	15.4	43	15.6	92	15.1	50	15.3
281–308	124	15.6	38	15.7	82	15.2	40	15.5
309–336	122	15.7	33	15.8	81	15.4	33	15.6
337–364	108	15.9	29	16.0	72	15.4	34	15.7
365–392	40	16.0	13	16.3	29	15.8	18	15.9
393–420	7	16.2	2	16.2	4	15.6	—	—
421–448	3	16.4	2	16.2	1	16.0	—	—
449–476	3	16.6	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	17.1
645–672	—	—	1	16.2	—	—	—	—
673–700	1	17.2	1	16.8	—	—	—	—
701–728	8	16.6	2	17.0	4	16.5	2	17.0
729–756	16	16.8	1	17.1	11	16.3	4	17.0
757–784	3	17.5	—	—	1	17.3	2	16.3
785–812	1	16.0	—	—	2	16.4	2	16.9
813–840	4	17.5	—	—	2	16.6	—	—
841–868	3	16.8	1	18.0	6	17.0	—	—
869–896	5	17.4	—	—	1	17.2	1	17.6
897–924	3	16.9	—	—	1	17.8	—	—
925–952	2	17.2	—	—	3	17.0	—	—
981–1008	1	17.8	1	16.5	—	—	—	—

ence, head length, head breadth and pelvic breadth (in our series it was intercristal width) but not with our results on stature. Although the sample included both male and female specimens, no differentiation was made in the summary.

Considering that the same relative standing has been found in the adult and infant in some of the physical measurements, it would be interesting to have a study made on negro and white, male and female adults, showing relative standing in stage of fusion. The infants whose carpals appeared earliest were the negro females, with negro males next, followed by the white females and the white males. The cuboid appeared in the same order found by Dunham, Jenss and Christie.[14]

SUMMARY

The white male babies were on the average longest as indicated by the recumbent

TABLE XVII

MEAN HEAD CIRCUMFERENCE OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Circumference	Subjects	Circumference	Subjects	Circumference	Subjects	Circumference
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	36.0	1	34.3	—	—	—	—
15–28	43	36.1	14	35.3	31	35.5	19	35.2
29–56	132	37.6	43	37.4	96	36.8	50	36.7
57–84	166	39.1	51	39.0	124	38.0	60	38.4
85–112	161	40.3	46	40.2	122	39.2	58	39.7
113–140	162	41.4	52	41.4	118	40.2	56	40.8
141–168	160	42.4	52	42.4	106	41.2	55	41.9
169–196	155	43.3	46	43.2	114	42.0	53	42.4
197–224	150	44.0	43	44.1	97	42.8	52	42.3
225–252	142	44.5	46	44.5	95	43.4	48	43.8
253–280	141	45.0	43	45.2	92	43.8	50	44.4
281–308	124	45.6	38	45.6	82	44.3	40	45.1
309–336	122	45.9	33	45.8	81	44.8	33	45.3
337–364	108	46.3	29	46.6	72	44.9	34	45.5
365–392	40	46.6	13	46.6	29	45.1	18	46.0
393–420	7	47.1	2	46.3	4	45.8	—	—
421–448	3	47.2	2	46.6	1	44.5	—	—
449–476	3	47.8	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	50.0
645–672	—	—	1	47.3	—	—	—	—
673–700	1	49.0	1	48.7	—	—	—	—
701–728	8	48.5	2	49.2	4	47.6	2	48.6
729–756	16	49.1	1	48.2	11	47.6	4	49.6
757–784	3	49.8	—	—	1	50.0	2	46.2
785–812	1	45.6	—	—	2	49.2	2	48.5
813–840	4	49.6	—	—	2	48.6	—	—
841–868	3	48.1	1	52.0	6	48.0	—	—
869–896	5	49.7	—	—	1	49.5	1	49.7
897–924	3	48.9	—	—	1	49.7	—	—
925–952	2	50.6	—	—	3	47.5	—	—
981–1008	1	49.7	1	48.3	—	—	—	—

length values (total, stem, head and trunk), widest in the head, chest and hips, and had the greatest expanse and density as measured by circumference of head and chest and by weight. The negro male babies were observed to be the largest group according to depth of chest, length of tibia and girth of upper arm. The negro female babies were the shortest group according to the recumbent lengths and narrowest according to width of chest and hips. The white female babies were shortest in head length and tibial length and narrowest in chest depth and smallest in circumference of abdomen, head, chest and upper arm and weighed the least of the four groups.

During the first year the negro female group had the largest average carpal area at all age levels from 29–392 days and the white males the smallest area. The average

TABLE XVIII

MEAN CHEST WIDTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Width	Subjects	Width	Subjects	Width	Subjects	Width
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	10.2	1	9.3	—	—	—	—
15–28	43	10.9	14	10.8	31	10.8	19	10.6
29–56	132	11.7	43	11.5	96	11.5	50	11.4
57–84	166	12.6	51	12.4	124	12.2	60	12.1
85–112	161	13.1	46	12.8	122	12.7	58	12.6
113–140	162	13.7	52	13.4	118	13.2	56	13.0
141–168	160	14.2	52	13.9	106	13.6	55	13.5
169–196	155	14.5	46	14.2	114	14.0	54	13.7
197–224	150	14.8	43	14.4	97	14.3	52	14.0
225–252	142	15.0	46	14.5	95	14.4	48	14.3
253–280	141	15.1	43	15.0	92	14.6	50	14.3
281–308	124	15.3	38	15.0	82	14.8	40	14.6
309–336	122	15.5	33	15.2	81	15.0	33	14.7
337–364	108	15.6	29	15.4	72	15.0	34	14.7
365–392	40	15.8	13	15.4	29	15.0	18	14.7
393–420	7	15.8	2	15.2	4	15.5	—	—
421–448	3	15.7	2	15.4	1	15.5	—	—
449–476	3	15.1	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	17.3
645–672	—	—	1	16.0	—	—	—	—
673–700	1	17.2	1	16.4	—	—	—	—
701–728	8	16.2	2	16.0	4	15.9	2	15.8
729–756	16	16.4	1	15.1	11	15.7	4	15.8
757–784	3	16.7	—	—	1	17.0	2	15.1
785–812	1	14.9	—	—	2	17.1	2	16.0
813–840	4	16.0	—	—	2	16.0	—	—
841–868	3	16.6	1	17.5	6	16.2	—	—
869–896	5	16.9	—	—	1	17.6	1	16.2
897–924	3	16.4	—	—	1	17.2	—	—
925–952	2	17.6	—	—	3	16.6	—	—
981–1008	1	18.5	1	16.6	—	—	—	—

carpal area is greater for negro males than for white females at every age level except 15–28, 57–84 and 85–112 days when the reverse is true.

The per cent of wrist size ossified, as measured by the total carpal area per unit of wrist area, was greatest for the negro females, least for the white males. The negro males and white females are not consistent in relative standing for the various age levels.

The widths of the radius and tibia at their metaphyses, and of the diaphysis of the tibia one-third of its length above the distal end, were smallest for the white female children, followed by the negro females and white males; the negro males had the greatest dimensions at most age levels. The lengths of the radius and the tibia were smallest for the white female group, then either the white males or negro females, and largest for the negro male infants. The

TABLE XIX

MALE CHEST DEPTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Depth	Subjects	Depth	Subjects	Depth	Subjects	Depth
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	9.2	1	9.1	—	—	—	—
15–28	43	9.8	14	9.6	31	9.9	19	9.6
29–56	132	10.3	43	10.2	95	10.2	50	10.0
57–84	166	10.8	51	10.7	124	10.5	60	10.5
85–112	161	11.0	46	11.0	122	10.8	58	10.8
113–140	162	11.3	52	11.3	118	11.1	56	11.1
141–168	160	11.5	52	11.6	106	11.3	55	11.2
169–196	155	11.7	46	11.8	114	11.5	54	11.6
197–224	150	12.0	43	12.0	97	11.6	52	11.8
225–252	142	12.1	46	12.2	95	11.8	48	12.0
253–280	141	12.3	43	12.5	92	12.0	50	12.0
281–308	124	12.4	38	12.6	82	12.2	40	12.2
309–336	122	12.6	33	12.7	81	12.3	33	12.3
337–364	108	12.6	29	12.9	72	12.3	34	12.4
365–392	40	12.8	13	12.8	29	12.5	18	12.1
393–420	7	12.8	2	12.4	4	12.6	—	—
421–448	3	13.3	2	12.7	1	11.7	—	—
449–476	3	12.9	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	13.5
645–672	—	—	1	13.3	—	—	—	—
673–700	1	12.0	1	13.4	—	—	—	—
701–728	8	12.8	2	12.8	4	12.8	2	12.4
729–756	16	12.7	1	12.5	11	12.4	4	12.3
757–784	3	14.0	—	—	1	12.3	2	12.2
785–812	1	12.8	—	—	2	12.9	2	12.6
813–840	4	13.4	—	—	2	13.2	—	—
841–868	3	12.8	1	14.6	6	12.9	—	—
869–896	5	13.1	—	—	1	12.8	1	12.7
897–924	3	13.3	—	—	1	13.2	—	—
925–952	2	12.9	—	—	3	13.2	—	—
981–1008	1	13.6	1	13.0	—	—	—	—

white male group had the smallest average width of epiphyses of the radius, the negro male next, then the white females, with the negro female group having epiphyses of the greatest average width.

Of the four carpal bones present during the first year the capitate appeared first, the hamate second, the triangular third and the lunate fourth.

The calcaneum and astragulus were present in every case but of the remaining tarsal bones the cuboid appeared first, the external cuneiform second, the internal cuneiform third, the middle cuneiform and scaphoid fourth and fifth, respectively.

Of the nineteen bones of the hand the epiphyses of the second and third metacarpal, of the second, third and fourth proximal phalanges and of the first distal phalanx were among the first to appear. The average ranking of each of the epiphyses of the hand did not vary more than a few places from one race or sex group to another.

The ten epiphyses of the five metatarsals and proximal phalanges varied in order

TABLE XX

MEAN CHEST CIRCUMFERENCES OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Circumference	Subjects	Circumference	Subjects	Circumference	Subjects	Circumference
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	32.6	1	31.3	—	—	—	—
15–28	43	33.5	14	32.6	31	33.6	19	32.6
29–56	132	35.5	43	35.4	96	35.0	50	34.6
57–84	166	37.6	51	37.6	124	36.5	60	36.7
85–112	161	39.2	46	38.7	122	38.0	58	38.3
113–140	162	40.6	52	40.3	118	39.4	56	39.5
141–168	160	41.7	52	41.3	106	40.4	55	40.5
169–196	155	42.6	46	42.2	114	41.4	53	41.3
197–224	150	43.3	43	43.1	97	42.1	52	42.0
225–252	142	44.0	46	43.4	95	42.6	48	42.6
253–280	141	44.5	43	44.2	92	43.2	50	43.0
281–308	124	45.3	38	44.6	82	43.7	40	43.8
309–336	122	45.7	33	45.4	81	44.3	33	43.7
337–364	108	45.9	29	45.8	72	44.5	34	44.3
365–392	40	46.7	13	46.1	29	44.9	18	44.1
393–420	7	46.8	2	45.0	4	46.0	—	—
421–448	3	46.9	2	45.2	1	44.2	—	—
449–476	3	47.7	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	51.0
645–672	—	—	1	47.0	—	—	—	—
673–700	1	49.5	1	51.0	—	—	—	—
701–728	8	47.8	2	47.8	4	46.9	2	47.5
729–756	16	48.0	1	47.0	11	46.4	4	48.0
757–784	3	50.2	—	—	1	48.0	2	45.3
785–812	1	46.0	—	—	2	48.2	2	47.8
813–840	4	48.0	—	—	2	42.6	—	—
841–868	3	48.8	1	51.0	6	47.4	—	—
869–896	5	49.2	—	—	1	50.0	1	49.0
897–924	3	48.3	—	—	1	50.0	—	—
925–952	2	52.0	—	—	3	50.3	—	—
981–1008	1	52.6	1	48.0	—	—	—	—

from one group to another, though the epiphyses of the first metatarsal and of the second, third and fourth proximal phalanges were always among the first to appear.

The distal epiphyses of the femur, tibia, fibula, radius, and ulna, the proximal epiphyses of the tibia, fibula, and radius and the capitellum were ranked in order of appearance. Of these the distal epiphysis of the femur appeared first and the proximal epiphysis of the tibia appeared second in all cases. The distal epiphyses of the tibia and capitellum shared honors for third and fourth places.

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TABLE XXI

MEAN ABDOMEN CIRCUMFERENCES OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Circumference	Subjects	Circumference	Subjects	Circumference	Subjects	Circumference
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	—	—	1	27.0	—	—	—	—
15–28	27	31.1	10	31.2	19	31.1	13	31.2
29–56	86	33.5	34	33.6	55	33.3	32	33.3
57–84	111	36.1	37	36.3	78	34.7	39	35.4
85–112	108	37.7	32	37.2	79	36.6	40	37.2
113–140	110	38.9	40	38.7	77	37.8	39	38.4
141–168	110	40.1	39	39.7	67	38.5	38	39.1
169–196	107	40.8	35	40.4	75	39.4	38	39.8
197–224	102	41.1	32	41.4	68	39.8	37	40.2
225–252	99	41.3	35	41.2	66	40.2	38	40.2
253–280	100	41.6	32	41.4	66	40.4	38	40.5
281–308	88	42.0	30	42.0	58	40.6	30	41.2
309–336	87	42.1	26	42.2	55	40.9	25	41.3
337–364	77	42.4	24	42.6	53	40.9	24	41.7
365–392	16	42.5	8	43.9	15	40.8	10	41.4
393–420	—	—	—	—	—	—	—	—
421–448	—	—	—	—	—	—	—	—
449–476	—	—	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	50.0
645–672	—	—	1	42.0	—	—	—	—
673–700	1	42.5	1	46.5	—	—	—	—
701–728	8	44.0	2	42.5	3	41.0	2	41.6
729–756	13	43.2	1	45.0	10	43.2	4	42.2
757–784	1	44.5	—	—	—	—	1	41.0
785–812	1	39.0	—	—	2	42.5	2	45.0
813–840	1	47.0	—	—	2	43.0	—	—
841–868	1	43.0	—	—	5	42.3	—	—
869–896	2	42.8	—	—	—	—	—	—
897–924	2	42.8	—	—	—	—	—	—
925–952	1	44.0	—	—	2	44.5	—	—

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TABLE XXII

MEAN INTERCRISTAL WIDTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Width	Subjects	Width	Subjects	Width	Subjects	Width
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	9.2	1	8.1	—	—	—	—
15–28	43	9.2	14	8.9	31	9.2	19	8.8
29–56	132	9.9	43	9.7	96	9.7	50	9.4
57–84	166	10.6	51	10.5	124	10.3	60	10.2
85–112	161	11.2	46	10.8	122	10.8	58	10.7
113–140	162	11.7	52	11.4	118	11.3	56	11.2
141–168	160	12.1	52	11.7	106	11.7	55	11.5
169–196	155	12.4	46	12.0	114	12.0	54	11.7
197–224	150	12.8	43	12.1	97	12.3	52	12.1
225–252	142	12.9	46	12.3	95	12.6	48	12.3
253–280	141	13.2	43	12.9	92	12.8	50	12.4
281–308	124	13.4	38	12.8	82	12.9	40	12.8
309–336	122	13.7	33	13.2	81	13.2	33	12.9
337–364	108	13.7	29	13.4	72	13.3	34	13.0
365–392	40	13.9	13	13.6	29	13.6	18	12.8
393–420	7	13.8	2	13.1	4	13.5	—	—
421–448	3	14.1	2	13.5	1	12.4	—	—
449–476	3	13.4	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	14.9
645–672	—	—	1	14.0	—	—	—	—
673–700	1	14.7	1	15.5	—	—	—	—
701–728	8	14.7	2	14.6	4	14.6	2	14.4
729–756	16	15.2	1	13.7	11	14.7	4	14.8
757–784	3	15.7	—	—	1	15.3	2	13.8
785–812	1	14.2	—	—	2	15.1	2	14.8
813–840	4	15.8	—	—	2	14.8	—	—
841–868	3	15.1	1	15.4	6	15.4	—	—
869–896	5	16.0	—	—	1	15.6	1	15.2
897–924	3	15.5	—	—	1	15.8	—	—
925–952	2	15.8	—	—	3	16.1	—	—
981–1008	1	16.9	1	14.4	—	—	—	—

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TABLE XXIII

MAXIMUM UPPER ARM GIRTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Girth	Subjects	Girth	Subjects	Girth	Subjects	Girth
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	8.8	1	9.0	—	—	—	—
15–28	43	8.9	14	8.9	31	8.8	19	8.8
29–56	132	9.5	43	9.8	96	9.4	50	9.6
57–84	166	10.2	51	10.6	124	10.0	60	10.3
85–112	161	10.8	46	11.0	122	10.5	58	10.9
113–140	162	11.3	52	11.6	118	10.9	56	11.4
141–168	160	11.7	52	11.9	106	11.3	55	11.6
169–196	155	12.0	46	12.1	114	11.7	53	11.9
197–224	150	12.4	43	12.4	97	11.9	52	12.1
225–252	141	12.6	46	12.6	95	12.1	48	12.3
253–280	141	12.8	43	13.0	92	12.3	49	12.4
281–308	124	13.0	38	13.0	82	12.5	40	12.8
309–336	121	13.1	33	13.2	81	12.7	33	12.7
337–364	108	13.1	29	13.4	72	12.8	34	12.9
365–392	40	13.4	13	13.4	29	12.9	18	13.0
393–420	7	13.4	2	12.6	4	13.1	—	—
421–448	3	13.7	2	12.8	1	11.8	—	—
449–476	3	13.7	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	13.0
645–672	—	—	1	13.4	—	—	—	—
673–700	1	14.2	1	14.0	—	—	—	—
701–728	8	13.4	2	13.8	4	13.4	2	13.7
729–756	16	13.8	1	14.8	11	13.5	4	13.7
757–784	3	14.1	—	—	1	14.0	2	12.8
785–812	1	13.6	—	—	2	13.8	2	13.0
813–840	4	14.2	—	—	2	14.0	—	—
841–868	3	13.4	1	16.1	6	13.8	—	—
869–896	5	14.5	—	—	1	14.4	1	14.0
897–924	3	12.7	—	—	1	14.0	—	—
925–952	2	14.1	—	—	3	14.3	—	—
981–1008	1	15.0	1	12.2	—	—	—	—

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TABLE XXIV

MEAN MAXIMUM THIGH GIRTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Girth	Subjects	Girth	Subjects	Girth	Subjects	Girth
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	14.2	1	14.8	—	—	—	—
15–28	43	15.1	14	15.0	31	15.5	19	15.3
29–56	132	16.6	42	17.2	96	17.0	50	17.0
57–84	166	18.4	51	19.0	123	18.3	60	18.9
85–112	161	19.8	46	19.7	122	19.8	58	20.2
113–140	162	21.0	52	21.2	118	20.9	56	21.5
141–168	160	22.0	52	22.2	106	21.8	55	22.4
169–196	155	22.8	46	22.7	114	22.6	53	23.2
197–224	150	23.4	43	23.3	97	23.3	52	23.8
225–252	142	23.6	46	23.6	95	23.6	48	23.6
253–280	141	23.9	43	24.0	92	24.0	50	23.9
281–308	124	24.2	38	24.1	82	23.7	40	24.4
309–336	122	24.4	33	24.6	81	24.0	33	24.2
337–364	108	24.2	29	24.6	72	24.3	34	24.6
365–392	40	25.0	13	24.7	29	24.5	18	24.7
393–420	7	24.9	2	23.1	4	24.2	—	—
421–448	3	25.1	2	23.5	1	20.5	—	—
449–476	3	26.0	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	29.0
645–672	—	—	1	28.2	—	—	—	—
673–700	1	28.0	1	28.5	—	—	—	—
701–728	8	24.6	2	24.5	4	24.7	2	25.5
729–756	16	25.3	1	26.5	11	24.7	4	26.5
757–784	3	25.2	—	—	1	26.0	2	23.2
785–812	1	26.1	—	—	2	25.0	2	26.0
813–840	4	26.5	—	—	2	26.2	—	—
841–868	3	24.7	1	28.2	6	27.1	—	—
869–896	5	26.8	—	—	1	26.0	1	26.3
897–924	3	27.1	—	—	1	25.0	—	—
925–952	2	25.8	—	—	3	27.6	—	—
981–1008	1	27.5	1	23.0	—	—	—	—

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TABLE XXV

MEAN TIBIAL LENGTHS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Length	Subjects	Length	Subjects	Length	Subjects	Length
days	number	cm.	number	cm.	number	cm.	number	cm.
1–14	2	8.4	1	8.1	—	—	—	—
15–28	43	8.6	14	8.6	31	8.8	19	8.6
29–56	131	9.1	43	9.1	96	9.0	49	9.0
57–84	166	9.6	50	9.9	124	9.4	59	9.6
85–112	161	10.1	46	10.4	122	9.9	58	10.2
113–140	162	10.6	52	10.8	118	10.3	56	10.6
141–168	160	10.9	52	11.3	106	10.7	55	11.0
169–196	155	11.3	46	11.6	114	11.1	54	11.2
197–224	150	11.6	43	12.0	97	11.3	52	11.7
225–252	142	11.9	46	12.1	95	11.7	48	12.1
253–280	141	12.2	43	12.6	92	12.1	50	12.5
281–308	124	12.6	38	13.0	82	12.3	40	12.9
309–336	122	13.0	32	13.4	81	12.6	33	13.3
337–364	108	13.2	29	13.9	72	13.0	34	13.6
365–392	39	13.4	13	14.1	29	13.2	18	13.4
393–420	7	13.4	2	13.7	4	13.4	—	—
421–448	3	13.5	2	14.1	1	12.4	—	—
449–476	3	14.0	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	15.7
645–672	—	—	1	17.5	—	—	—	—
673–700	1	17.6	1	18.7	—	—	—	—
701–728	8	15.4	2	17.6	4	15.7	2	18.4
729–756	16	16.4	1	17.4	11	16.2	4	17.2
757–784	3	17.3	—	—	1	18.1	2	16.8
785–812	1	16.0	—	—	2	17.2	2	17.4
813–840	4	17.0	—	—	2	15.4	—	—
841–868	3	16.3	1	18.5	6	16.6	—	—
869–896	5	18.2	—	—	1	18.1	1	18.0
897–924	3	17.0	—	—	1	17.3	—	—
925–952	2	18.6	—	—	3	16.3	—	—
981–1008	1	16.3	1	17.9	—	—	—	—

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TABLE XXVI

MEAN BODY WEIGHTS OF MALE AND FEMALE, WHITE AND NEGRO INFANTS

Age	Male				Female			
	White		Negro		White		Negro	
	Subjects	Weight	Subjects	Weight	Subjects	Weight	Subjects	Weight
days	number	gm.	number	gm.	number	gm.	number	gm.
1–14	2	3,576	1	3,130	—	—	—	—
15–28	43	3,674	14	3,463	31	3,579	19	3,432
29–56	132	4,370	43	4,287	96	4,104	50	4,058
57–84	166	5,186	53	5,127	125	4,758	60	4,865
85–112	161	5,900	46	5,769	121	5,500	58	5,576
113–140	162	6,630	52	6,586	118	6,108	56	6,210
141–168	160	7,292	52	7,185	106	6,672	55	6,813
169–196	155	7,839	46	7,701	114	7,237	54	7,272
197–224	150	8,307	43	8,231	97	7,668	52	7,747
225–252	142	8,707	46	8,540	94	8,140	48	8,129
253–280	142	9,116	43	9,124	92	8,496	49	8,400
281–308	124	9,483	38	9,366	82	8,767	40	8,943
309–336	121	9,801	33	9,719	80	9,138	33	9,051
337–364	108	10,051	29	10,096	72	9,307	34	9,327
365–392	40	10,384	12	10,225	29	9,546	18	9,348
393–420	7	10,309	2	9,128	4	9,662	—	—
421–448	3	10,413	2	9,558	1	8,130	—	—
449–476	3	10,658	—	—	—	—	—	—
617–644	—	—	—	—	—	—	1	12,701
645–672	—	—	1	11,793	—	—	—	—
673–700	1	12,927	1	14,061	—	—	—	—
701–728	9	11,630	2	12,418	4	11,651	2	12,350
729–756	16	12,190	2	12,247	11	11,330	4	12,616
757–784	3	12,938	—	—	1	13,381	2	10,149
785–812	1	11,113	—	—	2	12,474	2	12,304
813–840	4	13,410	—	—	2	12,022	—	—
841–868	3	11,793	1	14,969	6	11,944	—	—
869–896	5	14,061	—	—	1	13,835	1	13,154
897–924	3	12,776	—	—	1	13,040	—	—
925–952	2	13,948	—	—	3	13,192	—	—
981–1008	1	14,628	1	11,000	—	—	—	—
1009–1036	1	19,504	—	—	—	—	—	—
1205–1232	—	—	—	—	1	11,340	—	—

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THE Twenty-Ninth Annual Meeting of the American Radium Society which will be held at the Seaside Hotel in Atlantic City on June 9 and 10, 1947, along with the great Centennial Convention of the American Medical Association, should be one of the best in the history of the organization. Although the attendance at San Francisco was exceptional a much larger registration is expected in Atlantic City, and those who plan to be present are urged to make hotel reservations immediately.

Cancer therapy and atomic physics are two of the scientific subjects uppermost in the minds of both laymen and physicians this year and the program of the American Radium Society offers a wealth of material in both fields. The President-Elect, Dr. A. N. Arneson, has arranged excellent symposia on tumors of the testicle and cancer of the uterus and cervix and has provided a series of papers dealing with the treatment of cancer of the skin, sinuses, larynx, esophagus, eye and other regions of the body. Discussions of cancer clinics, new methods of diagnosis and improved techniques in radiation therapy have also been planned.

The Janeway Lecture on Tuesday afternoon is to be given by Dr. Robert S. Stone of San Francisco. He has chosen as the title of his lecture "Neutron Therapy and Specific Ionization." This subject is timely and of unusual interest. Since the chain reaction and the atomic bomb have become so important, the neutron has assumed the center of the stage in nuclear physics and Dr. Stone is one of the few radiologists in this country capable of adequately presenting the subject of neutron therapy. Both his prewar experience with the cyclotron and his close association with atomic research during World War II have provided him with an imposing array of material for this presentation.

Many radiotherapists are of the opinion that the training provided for young men entering their specialty in this country is poorly organized and that there is much room for improvement. The Committe on Education has made a preliminary study of this subject during the past year and reports and recommendations will be made at one of the business sessions.

As a result of the efforts of the American Society for the Control of Cancer and a group of public spirited individuals, the people of our country are being stimulated to take an active interest in an all-out attack on the cancer problem. The American Radium Society, which includes in its membership many of the outstanding cancer therapists of America, is in a position to provide much of the "know how" so essential to a wider distribution of efficient treatment for cancer patients. For this reason the Society faces a rapid growth and an expanding sphere of usefulness during the next few years.

The officers of the organization wish to extend a cordial invitation to its annual meeting to all scientists and physicians interested in the care of neoplastic diseases.

CHARLES L. MARTIN

FREDERICK MANWARING LAW
1875–1947

DR. FREDERICK Manwaring Law died on February 12, 1947, at his home in Flushing, New York, at the age of seventy-one, after a lingering illness. His death was due to amyotrophic lateral sclerosis from which he had suffered for almost two years.

Dr. Law was born in Willoughby, Ohio, on August 29, 1875. Like his friend Eugene Caldwell, he had a degree in Electrical Engineering—a Bachelor of Science degree which he received from Drexel Institute of Technology, Philadelphia, in 1894. Seven years later—in 1901—he received his M.D. at the University of Pennsylvania.

In 1917 Dr. Law accepted a captaincy in

the Medical Corps of the Army in World War I, and he was promoted to Major on June 4, 1918. He served as roentgenologist at Base Hospital 115 in Vichy, France, which was a general hospital specializing in head injuries.

From 1902 until his enforced retirement in 1945, because of poor health, Dr. Law was identified with the Manhattan Eye, Ear and Throat Hospital. He was Clinical Assistant from 1902 to 1907, Assistant in Surgery from 1907 to 1912, and Roentgenologist from 1910 to 1945. He was retained by the hospital long past the retirement age on grounds of being irreplaceable. He had a clinical knowledge of the ear and nose, and could tell, from the roentgenogram, how the cells would feel to the curette. It was my privilege to be his assistant at the hospital from 1931 to 1936, from which association a pleasant casual acquaintance developed into a friendship that endured until his death.

Dr. Law's book "Mastoids, Roentgenologically Considered" initiated the series published by Paul B. Hoeber, known as the Annals of Roentgenology. This book, Volume I of the series, appeared in 1920, and the first edition was illustrated with twenty-one plates which were actual photographic prints, with explanatory text in English, Spanish and French. A second edition, illustrated with halftones, was less highly prized, for obvious reasons; but the first edition is a collector's item. In 1933, Dr. Law contributed the fifteenth volume of the Annals of Roentgenology, entitled "Nasal Accessory Sinuses."

Dr. Law used glass plates as long as he could get them, and was a devotee of stereoscopic examination. He was a clinician with an engineering type of mind. The art has advanced since he wrote his two books, but his philosophy of work in the conclusion of his book on "Nasal Accessory Sinuses" is still good:

"A proper roentgen examination of the sinuses requires as much care and attention to details as an architect's drawing, and when this care becomes universal among roentgenologists, the science will have advanced to the high standard required by all true scientific measures."

Dr. Law was a diplomate of the American Board of Otolaryngology and of the American Board of Radiology, and a fellow of the American College of Radiology. He also held memberships in many other scientific and medical societies, among them the American Roentgen Ray Society and the New York Roentgen Society, of which he was past president, the American Academy of Ophthalmology and Otolaryngology and the American Institute of Engineers.

Dr. Law is survived by his wife, Mrs. Bess Glen Law, to whom he was married in 1913.

Ramsay Spillman

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Haddon Hall, Atlantic City, N. J., Sept. 16–19, 1947.

American Radium Society
Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: Seaside Hotel, Atlantic City, N. J., June 9–10, 1947.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: 1947, to be announced.

American College of Radiology
Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting: Haddon Hall, Atlantic City, N. J., June 8, 1947.

Section on Radiology, American Medical Association
Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: Atlantic City, N. J., June 9–13, 1947.

Alabama Radiological Society
Secretary, Dr. John D. Peake, Mobile Infirmary, Mobile Ala. Next meeting time and place of Alabama State Medical Association.

Arkansas Radiological Society
Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

Brooklyn Roentgen Ray Society
Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N. Y. Meets monthly on fourth Tuesday, October to April.

Buffalo Radiological Society
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

Chicago Roentgen Society
Secretary, Dr. T. J. Wachowski, 310 Ellis Ave., Wheaton, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. George L. Sackett, 10515 Carnegie Ave. Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

Dallas-Fort Worth Roentgen Study Club
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

Denver Radiological Club
Secretary, Dr. W. C. Huyler, 1619 Milwaukee, Denver 6, Colo. Meets third Friday of each month at Department of Radiology, Colorado School of Medicine.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida Radiological Society
Secretary, Dr. J. M. Dell, Jr., 333 W. Main St., S., Gainesville, Fla. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

Illinois Radiological Society
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets second Sunday in May.

Iowa X-Ray Club
Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

Kentucky Radiological Society
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Louisiana Radiological Society
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

Michigan Association of Roentgenologists
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Chauncey N. Borman, 802 Medical Arts Bldg., Minneapolis 2, Minn. Two meetings yearly, one at time of Minnesota State Medical Association, the other in the fall.

Nebraska Radiological Society
Secretary, Dr. O. A. Neely, 924 Sharp Bldg., Lincoln,

* Secretaries of societies not here listed are requested to send the necessary information to the Editor.

Neb. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library

NEW HAMPSHIRE ROENTGEN RAY SOCIETY
Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. Hemphill, 323 Professional Bldg., Charlotte 2, N. C. Meets in May and October.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. Henry Snow, 1061 Reibold Bldg., Dayton, Ohio. Meets during annual meeting of Ohio State Medical Association.

OKLAHOMA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. P. E. Russo, 230 Osler Bldg., Oklahoma City, Okla. Three regular meetings annually.

ORLEANS PARISH RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. C. L. Stewart, Jefferson Hospital. Meets first Thursday of each month, October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. L. M. J. Freedman, 115 South Highland Ave. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

PORTLAND ROENTGEN CLUB
Secretary, Dr. Selma Hyman, University of Oregon Medical School, Portland, Oregon. Meets monthly 2d Wednesday, 8:00 P.M., Library of University of Oregon Medical School.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Robert M. Lowman, Grace-New Haven Community Hospital, New Haven 11, Conn. Meets bimonthly on second Thursday, at place selected by Secretary.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. ASSN.
Secretary, Dr. Moris Horwitz, 2009 Wilshire Blvd., Los Angeles 5, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. W. H. Seward, Orange Memorial Hospital, Orange, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY
Secretary Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

SAN DIEGO ROENTGEN SOCIETY
Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph Levitin, 516 Sutter St., San Francisco 2, Calif. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year at Lane Hall, Stanford University Hospital, and second six months at Toland Hall, University of California Hospital.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

SHREVEPORT RADIOLOGICAL CLUB
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May inclusive. Room 203, Service Memorial Institute, 426 N. Charter St., Madison.

UTAH RADIOLOGICAL CONFERENCE
Secretary, Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City 1. Meets 1st and 3rd Thursdays monthly from 7:30 to 10 P.M., Salt Lake County General Hospital, September to June.

UTAH STATE RADIOLOGICAL SOCIETY
Secretary, Dr. M. Lowry Allen, Judge Bldg., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

VIRGINIA RADIOLOGICAL SOCIETY
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St. Richmond, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle.

Meets fourth Monday each month, October through May, College Club, Seattle.

X-Ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly, third Thursday evening.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

Mexico

Sociedad Mexicana de Radiologia y Fisioterapia
General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

British Empire

British Institute of Radiology Incorporated with the Roentgen Society
Medical Members' meeting held monthly on third Friday at 2:30 p.m. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 23 Welbeck St., London, W.1 England.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 p.m. at the Royal Society of Medicine, 1 Wimpole St., London.

Canadian Association of Radiologists
Honorary Secretary, Dr. E. M. Crawford, 2100 Marlowe Ave., Montreal 28, Que. Meetings January and June.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Société Canadienne-Francaise d'Electrologie et de Radiologie Médicales
Secretary, Dr. Origéne Dufresne, 4120 Ontario St., East, Montreal, P. Q.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital. K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

South America

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Sociedad Peruana de Radiologia
Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306 Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

Continental Europe

Société belge de radiologie
General Secretary, Dr. S. Masy, 111 Avenue des Alliés, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

Ceskoslovenská společnost pro röntgenologii a radiologii v Praze
Secretary: MUDr. Roman Blána, Praha XII, Korunní 160, Czechoslovakia.

Polish Society of Radiology
First post-war inaugural meeting will be held in Warsaw, May 22 and 23, 1947.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. L. Zgliczynski, Nowogrodzka 59, Warsaw, Poland. Meets monthly.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 p.m.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. Babaiantz, Geneva.
Secretary for German language, Dr. Max Hopf, Effingerstrasse 49, Bern. Meets annually in different cities.

PRELIMINARY PROGRAM

TWENTY-NINTH ANNUAL MEETING OF THE AMERICAN RADIUM SOCIETY

The Twenty-ninth Annual Meeting of the American Radium Society will be held at the Seaside Hotel, Atlantic City, New Jersey, on Monday and Tuesday, June 9 and 10, 1947, under the Presidency of Dr. Charles L. Martin of Dallas, Texas. The scientific program has been arranged as follows:

Monday, June 9, 1947

MORNING SESSION

8:30 A.M.: Executive Session

9:00 A.M.: Scientific Session.

1. Presidential Address. Charles L. Martin, M.D., Dallas, Texas.
2. The Use of Radon Seeds (Tubules) in the Treatment of Benign and Malignant Conditions. Ira I. Kaplan, M.D., B.Sc., New York, New York.
3. Cancer Detection Clinics. J. Robert Andrews, M.D., Cleveland, Ohio.
4. Dentistry and Its Relationship to the Treatment of Cancer. Andrew J. Ackerman, D.D.S., New York, New York.
5. Radioactive Sodium in the Treatment of Leukemia; Preliminary Report. Titus C. Evans, M.D.,* and Maurice Lenz, M.D., New York, New York.
6. The Treatment of Keloids by Irradiation and Electrocoagulation. George E. Pfahler, M.D., and George P. Keefer, M.D.,* Philadelphia, Pennsylvania.
7. Some Considerations of the Therapy of Hemangiomas. Eugene P. Pendergrass, M.D., James C. Kalterjohn, M.D.* and James B. Butchart, M.D.,* Philadelphia, Pennsylvania.

AFTERNOON SESSION

2:00 P.M.: Executive Session.

2:20 P.M.: Scientific Session.

8. Testis Tumors. Milton Friedman, M.D., New York, New York.
9. Testis Tumors. Lloyd G. Lewis, M.D.,* Washington, D. C.
10. Testis Tumors. Eugene T. Leddy, M.D., Rochester, Minnesota.
11. Testis Tumors. Robert A. Moore, M.D.,* St. Louis, Missouri.

4:00 P.M.: JANEWAY LECTURE

NEUTRON THERAPY AND SPECIFIC IONIZATION

Robert S. Stone, M.D.* San Francisco, California.

7:00 P.M.: ANNUAL DINNER

Presentation of the Janeway Medal to Dr. Robert S. Stone.

Tuesday, June 10, 1947

MORNING SESSION

8:30 A.M.: Executive Session.

9:00 A.M.: Scientific Session.

12. Carcinoma of Cervix; Results from Radiation Treatment. John F. Hynes, M.D., Wilmington, Delaware.
13. Radon Treatment of Cancer of the Cervix Uteri; A Detailed Report of about 200 Patients Treated by an Unusual Technique. Frank E. Simpson, A.B., M.D., and J. Ernest Breed, M.D., Chicago, Illinois.
14. Carcinoma of the Cervix Uteri; Five Year Results in 790 Patients. Lawrence A. Pomeroy, M.D., Cleveland, Ohio.
15. Carcinoma of the Cervix; A Study of Five to Eleven Year End Results. William E. Howes, M.D., Brooklyn, New York.
16. Precision in Interstitial Radiation of Carcinoma of the Cervix. James A. Corscaden, M.D., New York, New York.
17. Dosage Measurements in Uterine Radium Treatment. James A. Nolan, M.D.* St. Louis, Missouri.
18. Cancer of the Uterine Corpus Following Irradiation for Benign Lesions. Frank R. Smith, M.D., and Samuel Bowden, M.D.,* New York, New York.

AFTERNOON SESSION

2:00 P.M.: Executive Session.

2:20 P.M.: Scientific Session.

19. Radio-Autography and Physical Aspects. Leonidas D. Marinelli, M.A., New York, New York.

* By Invitation.

20. Beta Radiation in Ophthalmology. Otto Glasser, D.Sc., and A. D. Ruedemann, M.D.,* Cleveland, Ohio.
21. Concentration Radiotherapy in Cancer of Mouth, Pharynx, and Larynx; Five Year Results in 235 Cases. Max Cutler, M.D., Chicago, Illinois.
22. Roentgen Treatment of Carcinoma of the Esophagus. Jacob R. Freid, M.D., New York, New York.
23. Lymphosarcoma of the Head and Neck. Daniel Catlin, M.D., New York, New York.
24. Extramedullary Plasmocytoma. Alfred F. Hocher, M.D., and Mason Morfit, M.D.,* New York, New York.
25. Treatment of Cancer of the Bladder. Shields Abernathy, M.D., Memphis, Tennessee.

AMERICAN COLLEGE OF RADIOLOGY EXPANDS PUBLIC RELATIONS PROGRAM

For some six years the Committee on Publicity of the American Roentgen Ray Society has enlisted the assistance of the Commission on Public Relations of the American College of Radiology in publicizing the annual scientific sessions. Essayists appearing on the program have been asked to send copies of their papers to the office of the College prior to the meeting. Under the direction of the College commission, Mr. Mac F. Cahal, executive secretary of the College, has prepared news releases on all papers containing material of public interest.

An advance story on the meeting is distributed to the press, and newspaper representatives are advised that press headquarters and daily press conferences will be maintained throughout the week of the meeting. At these press conferences releases on scientific papers are distributed for release after the papers were presented.

The results in previous years have been gratifying and this activity has become an integral part of the annual meetings of the Society. A large amount of favorable publicity, educating the public concerning the contributions and new advancements of radiology, has appeared in the nation's press. In addition to the AP, UP, INS, and Science Service, representatives of the local press and science writers from some of the larger metropolitan dailies customarily attend the scheduled press conferences. The purpose of the program is not so much to create publicity as it is to assist reporters in getting factual information, thus avoiding distorted, sensational, or inaccurate news reports.

A generous grant of funds from the X-Ray Section of the National Electrical Manufacturers Association to the American College of Radiology has enabled the Commission on Public Relations to expand its program this year. The press relations program is no longer confined to the week of the annual meetings of these two scientific societies, but is sustained throughout the year.

The editor of the American Journal of Roentgenology and Radium Therapy has arranged with the publishers to send advance page proof of each issue to the College office. Each month one or more news stories are prepared from the papers appearing in that issue. The publisher wires Mr. Cahal a few days before the issue is mailed and the press releases are mailed out for release on the date of publication, thus giving the story the essential element of timeliness. Releases are distributed to members of the National Association of Science Writers, wire services, state and county medical journals, and health publications.

This expanded and valuable activity of the College has been made possible through the generosity of the good friends of radiology in the manufacturing industry who compose the X-Ray Section of the National Electrical Manufacturers Association. It will be of worth-while benefit to the specialty of radiology.

BETATRON RESEARCH IN MULTI-MILLION VOLT RANGE

Plans have been completed at the National Bureau of Standards for the erection of two betatrons, enabling scientists there to extend research, measurements, and standards development into the 50 and 100 million volt range.

Two immediate problems calling for extensive investigation are the determination of measurement techniques and the formulation of precautionary principles in the use of the betatron for cancer treatment.

For the past twenty years, the National Bureau of Standards has played a central role in the development of standards for roentgen-ray dosage measurement and protection. The field has been covered thus far only up to 1.5 million volts. For this purpose, the Bureau now has one of the best equipped roentgen-ray laboratories in the world. Because of its facilities and its experience in the field of radioactivity as well as roentgen rays, outside organizations are looking to the National Bureau of Standards for extension of roentgen-ray measurement activities into the newly opened multimillion volt range.

The betatron is a device for producing electrons or roentgen rays of extremely high energies and frequencies. Both as a roentgen-ray device and as an electron beam generator, the betatron has unusual potentialities in the fields of medical, biological, industrial, and nuclear research.

As a medical tool, the betatron can provide roentgen rays suitable for cancer treatment under conditions long dreamed of but never realized. With 20 million volt radiation, it is possible to deliver to a subsurface tumor all the radiation it can stand and yet not seriously injure the skin. Recent research has indicated that the electron beam may also be used directly in therapy, for the beams have the property of passing through the surface and subsurface tissue with negligible absorption. Yet at a controllable depth, all of the energy of the electron beam is given up and absorbed by a tumor.

The problems of protection in both the medical and industrial applications of high voltage radiation are immeasureably greater in the multimillion volt range than in the lower regions heretofore encountered. Heavy protective barriers and expensive over-all installations are required, but the exact protection measurements and techniques are as yet unknown. One of the aims of the Bureau study is to discover the necessary thicknesses and types of construction that will give maximum protection with lowest over-all costs. Industrial use, in particular, presents difficulties not encountered in the medical applications, and the establishment of safe working conditions for industrial betatron use is one of the principal objectives.

The betatron is also an important tool in nuclear or atomic research. Many nuclear transformations are brought about simply by exposing materials to the powerful roentgen-ray beam. It is planned to make a systematic study of these transformations, which constitute a phase of atomic research virtually untouched at present.

Some of these transformation processes may take place when the human body is exposed to radiation, and it therefore becomes essential that they be thoroughly understood in connection with any biological or medical experiments. An understanding of these processes will also contribute materially to an understanding of the general atomic picture.

In 1946 Congress authorized and appropriated funds for the construction of a special building and the installation of a betatron at the Bureau. The betatron was designed to operate up to 50 million volts, although the building was designed to house much larger equipment as it became available, equipment up to 150 million volts and probably higher. While the building designs have been completed, the program has been retarded by the sharp increase in building costs since the appropriation estimates were made. The action of Congress is waited before proceeding with the construction program.

The main chamber in which the betatron

is to be housed, and the roentgen rays produced, will be completely buried underground and covered by several feet of concrete and earth. This is to prevent any direct radiation from escaping and harming nearby workers. The sensitive measuring equipment will be housed in an adjoining smaller room. In combination with these two rooms, facilities have been designed for determining the protective values of concrete and other materials, under conditions that will permit of their broad interpretation in the medical and industrial roentgen-ray field.

This latter point is of particular importance, since it is almost impossible to obtain this information with any of the existing or contemplated betatron installations. Requirements for this work are such that the buildings must be specially designed and constructed just for the purpose of determining protective values. The operators of the equipment will be separated from the betatrons by a concrete labyrinth and a 5 foot thick concrete wall, operating all equipment by remote control devices.

The first betatron called for will operate up to 50 million volts. Although this is not the largest device available, it is essential to provide for the production of roentgen rays from the low voltage of 1 million up to the higher 50 million volts. The region between 1 and 20 million volts is of extreme importance in medicine and biology. Large instruments, unfortunately, cannot operate successfully in this lower range.

The 1947 budget request calls for the addition of a 100 million volt betatron which will enable the Bureau to extend its studies above the 50 million volt limit of the smaller instrument. It is in this higher region that atomic and nuclear phenomena begin to become more evident.

Broad cooperative programs of research are planned with the National Cancer Institute and the Carnegie Institution of Washington. The National Cancer Institute has excellent facilities for biological investigation, while the Carnegie Institution has available both a cyclotron and a Van de Graaff generator. Acquisition of betatron facilities by the National Bureau of Standards, in conjunction with its established radioactivity and roentgen-ray laboratories, serves to round out the biological, medical, and biophysical radiation facilities of the Washington area in the high energy radiation range.

STAFFORD L. WARREN BECOMES DEAN OF NEW MEDICAL SCHOOL

Dr. Stafford L. Warren, Professor of Radiology at the University of Rochester, School of Medicine and Dentistry, has resigned to become Dean and Professor of Biophysics of the new medical school of the University of California at Los Angeles. Dr. Warren who began his new duties on February 1, 1947, was a member of the University of Rochester staff for twenty-one years. During the war he served as chief of the medical division for the atomic bomb project under the Manhattan District, for which he received the Distinguished Service Medal in 1945.

Dr. Warren will supervise plans for the medical school buildings and a university hospital of 500 beds on the campus, and will assemble a faculty and staff for the new medical school, which will be ready for its first class about 1948 or 1949.

To the Editor:

I have recently learned on good authority that Dr. Robert Kienböck, of Vienna, who was and is known to many American radiologists, is still living in Vienna, and doing rather poorly physically because of a cerebral hemorrhage. I am sure if some of our colleagues would send parcels of food, they would be greatly appreciated. His address is: Dr. med. Robert Kienböck, Klumpfelberggasse 3, Vienna 17, Austria.

James T. Case

NOTICE TO APPLICANTS AND DIPLOMATES OF THE AMERICAN BOARD OF RADIOLOGY

There are many Diplomates and candidates with applications on file whom we are unable to reach from their last known ad-

dress. During and since the war many Radiologists have changed locations and now have a different address than appears in the records of the Board kept in the Secretary's office.

It is very important that these records be accurate and it is therefore urged that all those Diplomates whose present address is different from that which appears in the new Third Edition of "The Directory of Medical Specialists," and all applicants whose address has changed since they filed their application, notify the Secretary immediately.

B. R. Kirklin, M. D., *Secretary*
American Board of Radiology
Mayo Clinic, Rochester, Minnesota

ST. LOUIS RADIOLOGICAL SOCIETY

At a recent meeting of the St. Louis Radiological Society Dr. Wendell G. Scott, St. Louis, was re-elected President, and Dr. Edwin C. Ernest, St. Louis, was re-elected Secretary for the coming year.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

LE FIBRO-MYOME UTÉRIN. Par J. Ducuing, Professeur de Clinique chirurgicale à la Faculté de Médecine de Toulouse: Directeur du Centre Anticancéreux. Paper. Pp. 541, with illustrations. Paris: Masson et Cie, 1946.

To a book reviewer there is no greater joy than to come upon a book which is all that the reviewer could expect or wish; and as far as its text is concerned, this outstanding work by Ducuing completely fulfills this reviewer's expectation.

The average reader might think that 541 pages devoted to the single subject of uterine fibromyoma seems excessive and must include a goodly amount of "padding," but this is not true. Those who are familiar with the literature of the subject are aware of the rather acrimonious controversy which has been going on for many years. The author is one of the outstanding surgeons of France, and at the same time, as Director of the Cancer Center at Toulouse, he is well versed in therapeutic radiology. He is eminently qualified, therefore, to deal with the subject, and he does so with a thoroughness and a fairness which cannot but impress the reader.

The book, which is printed on excellent paper, is divided into twelve chapters. In chapter I (3 pages) the author briefly gives and discusses his statistics which include 580 cases treated between 1919 and 1933, 547 cases treated between 1934 and 1942 (not previously reported), and 173 cases treated in 1942 and 1943. In chapter II (2 pages) he breaks down his statistics according to the age of the patients and makes pertinent comments on the age factor. In chapter III (2 pages) the large group of cases is studied from the point of view of the age of incidence of menstrual function. In chapter IV (11 pages) he analyzes his statistics in relation to the problem of fibromyoma and pregnancy and makes pertinent comments. In chapter V (3 pages) the author analyzes his series of cases from the standpoint of fibroma and spontaneous menopause. In chapter VI (12 pages) he analyzes and classifies them according to their salient anatomical and clinical features. Chapter VII (173 pages) is devoted to the anatomy and physiology, normal and pathological, of the uterus, fibromyoma, the ovary, the blood circulation of these structures, and to deductions concerning the mechanism of hemorrhage and the pathogenesis of fibromyoma. In chapter VIII (62 pages) the author brings out the clinical signs, certain complications and clinical forms of fibromyoma. Chapter IX (27 pages) deals with errors in diagnosis and methods of avoiding them. Chapter X (96 pages) deals with the therapeutic indications and techniques, surgical or radiologic. Chapter XI (68 pages) deals with the results of treatment. Chapter XII (28 pages) deals with pathologic changes in the pelvis, in the fibroids themselves, in the uterus and ovaries, and also with the physiology of the irradiated ovary. Finally, the book ends with a complete index, a list of authors cited, and a list of illustrations.

This is the most thorough and sanest presentation of the subject which the reviewer has ever read. The reader cannot fail to be impressed by the transparent honesty of the author. Surgeons, radiologists, and others who may be interested, could learn much from this book. It is especially interesting for a radiologist because the author, although himself an eminent surgeon, does not hesitate to advise roentgen treatment in 80 per cent of his cases of uterine fibromyoma, and he advises surgical treatment in only 20 per cent of his cases. Some readers may find fault because the bibliography includes few writers outside of France and Germany, but since the controversy over this question has been greatest in France, and since most of the outstanding writings have come from that country, perhaps the author should not be censured too much.

A. U. DESJARDINS

PRINCIPLES IN ROENTGEN STUDY OF THE CHEST. By William Snow, M.D., Director of Radiology, Bronx Hospital; Roentgenologist-in-charge, Harlem Hospital, New York City. Cloth. Price, $10.00. Pp. 414, with 508 illustrations. Springfield, Illinois: Charles C Thomas, 1946.

In this monograph covering the roentgen diagnosis of diseases of the chest, the author, as

stated in his preface, has two objects in view: to correlate the history and physical signs of the illustrative cases presented with the roentgenographic findings, and to include principles of physiology and pathology necessary for roentgen interpretation. By the use of serial roentgenograms he demonstrates the changing roentgen picture in the course of a disease and the response to treatment. The captions under many of the illustrations give a short résumé of the history and physical findings. Each chapter is begun with a description of the pathological changes of the disease under consideration.

The Chest Roentgenogram is the title of the first chapter which includes short descriptions of stereoscopy, positioning of the patient, technique for roentgenograms of the chest and photofluorography. The second chapter describes the average lung, a term used because a normal lung, free of all disease, is a rare condition. The author states that the lung is changing continually due to infections which leave residue; to foreign material such as coal dust taken up by the lymphatic system; to aging of tissue; to changes of the circulation and other causes. For this reason he prefers to speak of the average lung for the age of the patient. The third chapter is devoted to the role of the bronchial tree in diseases of the lungs. In this he endeavors to clarify many phenomena, often not clearly recognized, and thus afford a more logical approach to treatment. He believes that without a knowledge of the part played by the bronchial tree, the roentgen pathological picture cannot be readily understood. The mechanism of the pulmonary changes is based on the fact that bronchial spasm, diseases of the bronchi, secretions and foreign materials may induce obstructive emphysema, atelectasis and edema. The remaining chapters, four to twenty-two, cover diseases of the lungs including one each devoted to special chest problems in children, to the circulatory system and to the thoracic cage.

The book is well printed and is of convenient size for ready reading. The illustrations are for the most part clear, demonstrating satisfactorily the change which the author wishes to show. A very minor objection is the fact that the multiplicity of illustrations prevent their arrangement on pages opposite the text.

Comparatively little mention is made of the question of thymic enlargement in infants and young children, of rheumatic pneumonitis, of the controversial subject of congenital cystic disease of the lungs and of the pulmonary changes in cystic fibrosis of the pancreas. In spite of these omissions the diseases which are included are treated in such a detailed manner that the book will be a very valuable reference work for the roentgenologist, the student of roentgenology, and the internist.

R. S. Bromer

X-Rays in Practice. By Wayne T. Sproull, Ph.D., Physicist, Research Laboratories Division, General Motors Corporation. Cloth. Price, $6.00. Pp. 615, with 297 illustrations. New York: McGraw-Hill Book Company, 1946.

This book attempts to cover practically every phase of the production of roentgen rays and of their application in industry and medicine. In addition, the fundamentals of natural and artificial radioactivity as well as electron diffraction are presented. Almost one-half of the text is devoted to roentgen-ray diffraction and crystallography, and the various methods of crystal analysis are described in great detail. Equally extensive are the chapters on roentgen-ray tubes and high voltage generators, roentgen-ray spectra, absorption, scattering and roentgen-ray measurement. The broad presentation of these subjects does not always make for easy reading. Salient facts alternate with irrelevant details, description of obsolete apparatus, commercial references and quotation of price estimates for equipment. The chapter "X-rays in the Medical Field (Radiology)" is not free from these faults, although it covers only twenty-seven pages. Into this small space is crammed information on exposure values, diaphragms, stereoscopes, planigraphs, kymoscopes, photofluoroscopes, cineradiography, dark room technique, dosimetry, survival curves, isodoses, supervoltage therapy, gamma-ray therapy, irradiation sickness, and radioactive isotope treatment.

Although many quotations from radiologists are cited in this chapter, notably regarding the therapeutic application of roentgen and gamma rays, the tenor of the presentation will hardly be in agreement with the viewpoint of most medical radiologists. A great number of references are given and a section "Questions and Answers" follows each chapter. The references are not always the best obtainable for the subject under discussion. One example of many

may be cited. The photoelectric exposure meter invented by Russell H. Morgan and described by him in several articles (see for instance "Medical Physics," p. 1281, Year Book Publishers, Chicago, 1944), is credited to the Westinghouse Manufacturing Company, and the reader is to refer to an article in *Aero Digest*, 1945 *45*, 112. One also misses in the large list of references such accepted textbooks as "Radiologic Physics" by Weyl, Warren and O'Neill, "Radiology Physics," by Robertson, "Modern Physics of Roentgenology," by Muncherian, and "Physical Foundations of Radiology," by Glasser, Quimby, Taylor and Weatherwax.

Otto Glasser

BOOKS RECEIVED

Clinical Radiology. A Correlation of Clinical and Roentgenological Findings. Edited by Captain George Utley Pillmore, MC(S), USNR, Chief Radiologist to the United States Naval Hospital, Philadelphia, during World War II; Former Past Assistant Surgeon, United States Navy, during World War I; Chief Radiologist to the United States Naval Hospital, Charleston, South Carolina, etc. In Two Volumes. Cloth. Price, $45.00. Pp. 1600, with 2484 illustrations on 1500 figures. Philadelphia: F. A. Davis Company, 1946.

The Lung. By William Snow Miller, Late Emeritus Professor of Anatomy, University of Wisconsin. Second edition. Cloth. Price, $7.50. Pp. 222, with 168 illustrations. Springfield, Illinois: Charles C Thomas, 1947.

Renal Tuberculosis and Roentgenologic Examination. (*Acta radiol.*, Supp. XIII.) By Ragnar Steinert. From the Oslo Municipal Hospital Ulleval, Department of Roentgenology (Chief: J. Frimann-Dahl, M.D.). Paper. Pp. 162, with 35 illustrations. Oslo, Norway: Grøndahl & Søns boktrykkeri, 1943.

A Handbook of Radiography. By John A. Ross, M.A. (Camb.), M.R.C.S. (Eng.), L.R.C.P. (Lond.), D.M.R.E. (L'pool). Visiting Radiologist, Alder Hey Children's Hospital, Liverpool; Hon. Radiologist, Warrington Infirmary, Warrington; Radiologist, General Hospital, Warrington, etc. Second edition. Cloth. Pp. 165, with 92 illustrations. London: H. K. Lewis & Co., Ltd., 1946.

Radiology for Medical Students. By Fred Jenner Hodges, M.D., Professor and Chairman, Department of Roentgenology, University of Michigan; Isadore Lampe, M.D., Associate Professor, Department of Roentgenology, University of Michigan; and John Floyd Holt, M.D., Assistant Professor, Department of Roentgenology, University of Michigan. Cloth. Price, $6.75. Pp. 424, with 103 illustrations. Chicago: Year Book Publishers, Inc., 1947.

Varices. Su Tratamiento Basado en la Flebografía. Por el Dr. F. Martorell, Jefe de la Sección de Cirugía Vascular del Instituto Policlínico de Barcelona. Cloth. Pp. 140, with 118 illustrations. Barcelona: Editorial Labor, S. A.

Confrontations: Radio-Anatomo-Cliniques. Publiées sous la direction de M Chiray, R.-A. Guttmann et J. Sénèque. Fascicule I. Paper. Price, 370 fr. Pp. 56, with 98 illustrations. Paris: Masson et Cie, 1946.

Applied Anatomy of the Head and Neck. For Students and Practitioners of Dentistry. By Harry H. Shapiro, D.M.D., Assistant Professor of Anatomy, College of Physicians and Surgeons, Columbia University. Second Edition—revised and reset. Cloth. Price, $10.00. Pp. 303, with 221 illustrations, including 41 in color. Philadelphia: J. B. Lippincott Co., 1947.

Trans-Vision Anatomy of Head Structures Involved in Problems of Oral Prosthesis. Cardboard. Pp. 17, with 11 color transparencies. Anatomical Studies by Alfred Feinberg, College of Physicians and Surgeons, Columbia University. Jersey City, N. J.: Wernet Dental Mfg. Co.

Radical Surgery in Advanced Abdominal Cancer. By Alexander Brunschwig, M.D., Professor of Surgery, University of Chicago. Cloth. Price, $7.50. Pp. 324, with 118 illustrations. Chicago: The University of Chicago Press, 1947.

The Royal Cancer Hospital Mechanically Sorted Punched Card Index System. Compiled by D. W. Smithers, M.D., M.R.C.P., D.M.R.; K.M.H. Branson, M. B., F.R.C.S., and H. O. Hartley, Ph.D. Paper. Pp. 102. London: The Royal Cancer Hospital, 1945.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

A SIMPLE METHOD FOR ROENTGENOGRAPHY OF THE CHEST PRESENTING MARKED VARIATIONS IN DENSITY*

By SIDNEY ALEXANDER, R. T.
NEW YORK, NEW YORK

FILTERS of semi-opaque material have been used for many years in roentgenography to compensate for the variations in density of structures under examination. This method of compensation has been employed especially in the roentgenography of the chest where marked variations in density are present due to various abnormal conditions such as, for example, marked deformities of the chest. This has been found necessary since a roentgen-ray exposure which was adequate for yielding detail in the denser lung area resulted in complete obliteration of other portions of the lung fields.

Hawley[3] demonstrated by the use of increased aluminum filtration that the sharpness of outline and a suitable spread of light values between the lightest and darkest areas can be obtained. He found by increasing the thickness of the aluminum filters up to 3 or 4 millimeters that the results were markedly improved. The filters were applied at the tube level and required about a 10 per cent increase in exposure. Sante[7] suggested that aluminum filters of from 1 to 6 mm. in thickness, as required, be placed in the tube filter slot so as to shield the normal side of the chest, thus compensating for variations in density of the lung fields. In this method the correct filter is obtained by trial and error. One may use a graduated filter of aluminum for the trial exposures, as suggested by Melot,[4] to aid in choosing the satisfactory filter for the particular case.

Other methods have been described in which black paper is placed over part of one or both of the screens in the cassette corresponding to the regions of lesser density. This, however, produces a sharp line of demarcation on the roentgen film and in patients with marked scoliosis it is difficult to avoid covering part of areas which require the full value of the exposure. Daniello[2] tried to overcome this difficulty by cutting the black paper to suit the distortion for a particular case. The paper is cut from a tracing of the outline of the spinal curvature obtained from a previous roentgenogram, which is then placed in its proper position in the cassette. A custom made exposure and compensating filter is the result. Although a line of demarcation is still produced, it avoids bisecting the lung fields improperly. This method is also one of trial and error and is not simple.

A review of the literature revealed a number of roentgenographic methods for use in these abnormal conditions. However, they all present various undesirable features and the need for improvement in techniques.

A simple method of exposing both lung fields individually and on one film without producing poor contrast, lung bisection and a sharp line of demarcation was devised and is reported here.

* From the Department of Internal Medicine, New York State Psychiatric Institute and Hospital, New York, N. Y.

Methods and Procedures. The first step is to measure the filter slot in the tube carriage and to locate the mid-point of the slot. A lead filter is cut equal to one-half of the filter slot opening. The thickness of this lead filter should be about $\frac{1}{8}$ of an inch, which is sufficient for absorbing any primary rays reaching it. The filter is placed so that one-half of the primary rays emanating from the roentgen tube will be absorbed by the filter, while the remaining rays will pass through the open unfiltered portion and reach the chest and film (Fig. 1 and 2). An exposure is thus made at any desired

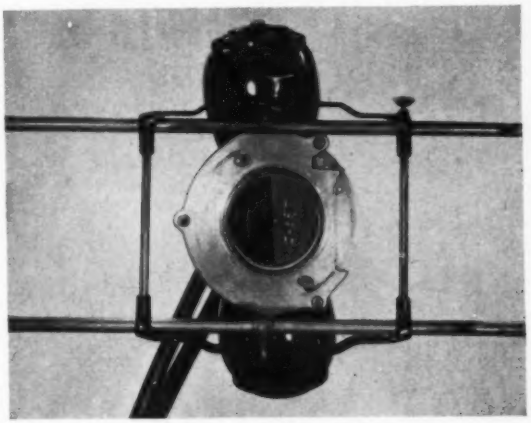

Fig. 1. Demonstrates the filter in place for exposure of one-half the lung field.

kilovoltage which affects only one-half of the film. The filter is now shifted to cover the other half of the filter slot, blocking off the half of the film which has been exposed, and another exposure is made at the desired kilovoltage, suitable for the corresponding half of the film. Thus both lung fields are exposed individually. The filter is used where a routine roentgen film of the chest discloses the need for this special technique.

Since the shifting of the filter is performed manually at the present time, it must be accomplished fairly rapidly, depending upon the cooperation of the patient and the ease with which the breath can be held. Slight breathing may result in some motion of the heart outline, but will not affect the lung fields appreciably.

Fig. 2. The resultant half lung field roentgenogram.

Several trial exposures may be necessary in the initial stages to demonstrate whether

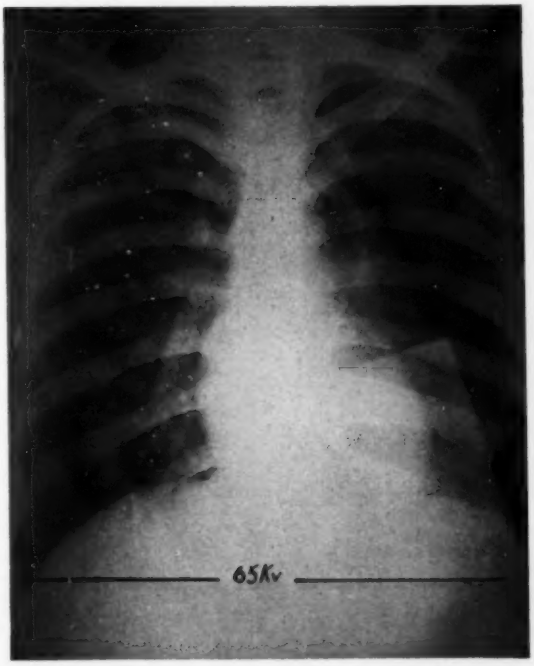

Fig. 3. Chest with paraffin block attached to lower left base. Routine exposure given.

Fig. 4. Individual exposures given to each half lung field, with the left (paraffin block) half given a 75 kv. exposure.

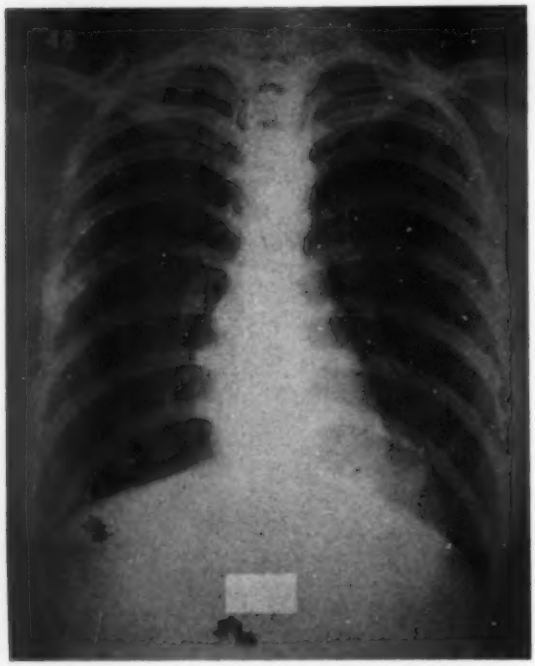

Fig. 5. Roentgenogram given routine exposure factors. Suspicious area in left base.

or not the lead filter is cut properly. The filter should meet at the midline of the aperture of the filter slot when it is shifted to cover first one half and then the other half of the aperture. It must not be too wide and overlap or too narrow, thus failing to meet properly at the midline of the slot aperture. If the filter is cut too narrow, an area of heavy exposure down the center of the film will result where the film receives

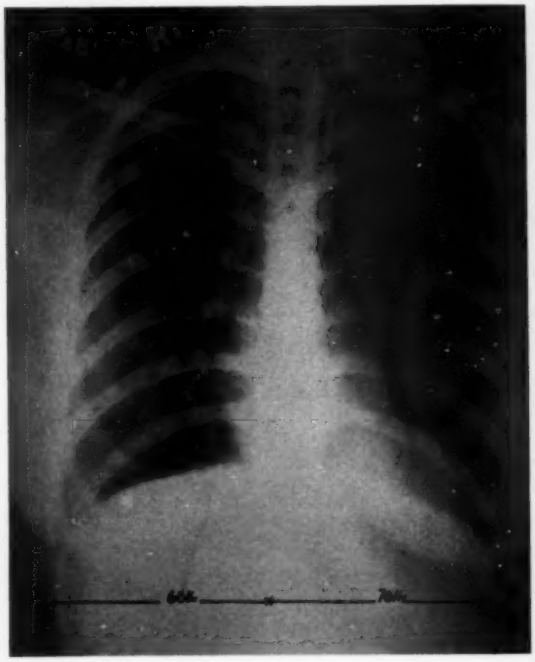

Fig. 6. Same chest, making use of individual half field exposures.

the full effect of both exposures. If the lead filter is too wide, a clear area down the center of the film will result since no primary rays will reach the film in the region in which the edges of the filter overlap. Should it be necessary to expose more or less than half of the lung area, combinations of lead filters may be devised to suit the particular case in accordance with the general principles previously outlined.

It was thought when one half of the chest area was given an increase in exposure over the other half that the latter might be affected by the resulting increase in scattered radiation. Accordingly test roentgenograms

were made to ascertain the extent of the effect on technique of such scattered radiation. Since no suitable cases were available for this study, an attempt was made to simulate a pathological condition within a chest area by the use of a paraffin block, 2 inches thick with a surface area 2½ by 5 inches, which was fastened over one area of the chest. Films were then exposed as follows:

A series of films were exposed in which the kilovoltage for the half containing the paraffin block was increased by 5 to 20 kv. over the normal half, i.e. 70, 75, 80 and 85 kv. The normal half was given a routine chest exposure for an 18 cm. chest, i.e. 65 kv., 100 ma. for 3/20 of a second.

Observation. The roentgenograms demonstrated that within an increase of from 5 to 15 kv. above the normal exposure, the effect of the scattered radiation on the normal half was slight. No adjustment in technique was necessary for the normal half chest area. However, where difference was greater than 15 kv., i.e. 20 kv. over the normal area, the scattered radiation produced a heavier exposed image on the normal half. It was found that this could be compensated for by a 5 kv. reduction in exposure for the normal side. The choice of a 5 kv. reduction was arbitrary since this was the smallest available kilovolt difference permissible with the type of apparatus used. There is the possibility that this adjustment of kilovoltage may vary with the type of abnormality encountered in the chest, and that perhaps in some instances less than 5 kv. would be adequate, or no adjustment at all may be necessary. Trial and experience will be a further guide to the roentgenologist and to the technician.

Discussion. This method of chest roentgenography, where marked variations in density exist, is a simple one requiring no costly additions to the equipment. The adaptability of this method to most types of equipment should be of further aid to the radiologist and technician in roentgenographing pathological chest areas. This method, as compared with existing procedures, produces roentgenograms of good density and contrast. There are no sharp lines of demarcation such as are produced by some of the other methods.

SUMMARY

1. A method producing individual exposures to chest areas with marked variations in density is presented.

2. The procedure is simple and requires only the use of a proper lead filter.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

GENITOURINARY SYSTEM

Cook, E. N., and Keating, F. R. Renal calculi associated with hyperparathyroidism. *J. Urol.*, Dec., 1945, *54*, 525–530.

The general impression has persisted since Mandl's original report that hyperparathyroidism is a rare disease and that it invariably manifests itself as osteitis fibrosa cystica. Albright proved the fallacy of this assumption. In a series of 67 cases Albright and his co-workers have shown that osteitis fibrosa cystica occurs in only one-third of the cases, in an additional third only mild bone changes are present and in a final third there is no evidence of bone changes. They also proved that renal calculi were much more common as a manifestation of hyperparathyroidism than bone involvement. The authors of the present article wish to emphasize this latter viewpoint.

At the Mayo Clinic there were 14 cases of hyperparathyroidism discovered from 1929 to 1943 and 18 cases from January, 1943 to July, 1944. Four of these 18 cases showed classic bone involvement and 14 showed renal calculi. The general symptoms are muscular weakness, lassitude, fatigue, constipation, and frequently polyuria and polydipsia. The renal symptoms are the same as would be encountered with any renal calculus. The symptoms referable to bone involvement include leg weakness, vague pains in the bones and joints, and pathological fractures.

The diagnostic criteria of hyperparathyroidism are hypercalcemia, hypophosphatemia, hypercalcinuria and hyperphosphaturia. Roentgenologic findings when there is associated disease of bone include extensive fibrocystic change, bone cysts, giant cell tumors, pathological fractures, miliary demineralization of the bones of the skull and subcortical resorption of the long bones. The treatment of the disease is surgical.

The authors wish to emphasize the importance of hyperparathyroidism as a cause of renal calculi and to urge its elimination as a diagnostic possibility in all cases of renal calculosis.—*P. M. Harvey.*

Twinem, F. P. Wilms' tumor in a 75 year old male. *J. Urol.*, March, 1946, *55*, 246–251.

Thirty-two cases of Wilms' tumor have now been reported in adults. The author reports the thirty-second case, which occurred in a seventy-five year old male, whose chief complaints were frequency and hematuria. An intravenous pyelogram showed a normally functioning right kidney with no visible dye in the left side of the urinary tract. A ureterogram showed a dilated left ureter infiltrated with tumor. Operation revealed what was thought to be a papillary carcinoma of the left kidney but which proved to be an embryoma or Wilms' tumor.

The patient died three months postoperatively. No irradiation was given.—*R. M. Harvey.*

Zucker, M. O. Congenital solitary pelvic kidney. *J. Urol.*, March, 1946, *55*, 256–259.

Stevens in 1937 estimated the frequency of solitary pelvic kidney as 1 in every 22,000 cases. Thirty-five cases have been reported in the literature. The author adds the thirty-sixth case, that of a twenty-four year old colored male who was admitted to the hospital for a palpable low midline mass. A flat film of the abdomen showed absence of renal shadows and no calcareous shadows. An intravenous urogram showed no dye in the usual location of the kidneys. A single kidney shadow was noted in the pelvis. The calices appeared normal and there was no evidence of an obstructive uropathy.

The author discusses the embryology of the kidney as an explanation for the occurrence of the anomaly. He emphasizes the fact that all genital anomalies should have complete pyelographic examinations because of the frequent coexistence of renal anomalies.—*R. M. Harvey.*

Zaslow, J., and Bernstein, M. Bilateral carcinoma of the adrenal cortex as a cause of severe backache with report of a case. *J. Urol.*, Nov., 1945, *54*, 409–412.

Eighty-two cases of adrenal carcinoma, sixteen per cent of which were bilateral, were found

by Wu in a search of the literature from 1803 to 1940. In the absence of recognizable hormonal changes, backache may be the presenting symptom. The authors report a case in a forty-four year old male who was admitted to the hospital complaining of low back pain, weakness, loss of weight and drenching night sweats. The symptoms had been present for six weeks. Physical examination revealed palpable lymph nodes in the axillae and groin. Routine laboratory studies were normal, except for anemia, rapid sedimentation rate and poor filling of the upper major calyx of the right kidney on intravenous urography. The right kidney and upper portion of the right ureter also showed lateral displacement. The roentgenologist suggested hypernephroma or adrenal tumor.

The patient died thirty-six hours postoperatively and autopsy revealed bilateral adrenal tumors which histopathologically proved to be carcinoma.—*R. M. Harvey.*

MacLean, J. T. Congenital valve in the upper ureter. *J. Urol.*, Oct., 1945, *54*, 374–380.

Valves at the normal openings of the ureters are said to occur in 20 per cent of all individuals but valves in other locations are extremely rare. The author reports the case of a congenital valve at the junction of the upper and middle thirds of the ureter occurring in a twenty-six year old male who complained of frequency, urgency and dysuria of one month's duration and right costovertebral pain which had been present for four days. Physical examination revealed tenderness in the right costovertebral angle. An intravenous urogram showed a normal left kidney and a moderate hydronephrosis on the right with apparent obstruction at the ureteropelvic junction and dilatation of the upper end of the right ureter.

Catheterization of the right ureter revealed an obstruction at the junction of the upper and middle thirds. This was confirmed by a right ureterogram which showed a complete obstruction at this point. No dye was recovered from the right kidney following phenolsulphonthalein injection. Operation disclosed a valve at the point of obstruction with a pinpoint-sized opening. The valve was removed and a temporary nephrostomy instituted. Three months after the operation a pyelogram showed a definite reduction in the size of the hydronephrosis of the right kidney. The right ureter was enlarged to 1 cm. throughout. There was no evidence of a stricture at the site of the removed valve.—*R. M. Harvey.*

Greene, L. E., and Kearns, W. M. Circumcaval ureter; report of a case with a consideration of the preoperative diagnosis and successful plastic repair. *J. Urol.*, Jan., 1946, *55*, 52–59.

Thirty-two cases of circumcaval ureter have been reported in the literature. In only 11 of these cases was the lesion recognized before death. In only 1 case was a preoperative diagnosis made before the authors add this second case. The diagnosis can only be made preoperatively by the roentgen ray. The anomaly is thought to be due to persistence of the embryonic right posterior cardinal vein, as the adult vena cava. The ureter is directed toward the midline and overlies the third and fourth lumbar vertebrae, giving it a sickle-shaped curve. In lateral views the circumcaval ureter hugs the spinal column and a ureterogram shows curving of the mid-portion of the ureter, convexity superomedial. Where obstruction results from the anomalous condition the ureterectasis is limited to the upper third of the ureter.

The authors report a case of this rare condition occurring in a twenty-nine year old male. An excretory urogram revealed a severe hydronephrosis of the right kidney and dilatation of the upper third of the right ureter. Survey film after introduction of an opaque catheter into the right ureter showed deviation of the ureter over the body of the third lumbar vertebra. The ureter exhibited a moderate curve with the convexity superomedial. A plastic repair was performed and an excretory urogram seven months later showed almost complete disappearance of the hydronephrosis and hydroureter.—*R. M. Harvey.*

MacLean, J. T., and Harding, E. W. Unilateral triplication of the ureter and renal pelvis. *J. Urol.*, Oct., 1945, *54*, 381–384.

Only 3 authentic cases of triplication of the ureter and renal pelvis have been reported prior to this article. The author discusses the embryology of the urinary system as it applies to reduplications of the ureters and renal pelves. A case is reported of a forty-one year old man who was admitted to the hospital complaining of left lumbar pain. An intravenous urogram disclosed a triple renal pelvis and triple ureter on the left side. Cystoscopic examination

showed two ureteral orifices on the left, two of the ureters fusing just before entering the bladder. The ureters did not cross at any point during their course from the kidney to the bladder.—*R. M. Harvey.*

Bowie, C. F., and Bors, E. Primary carcinoma of the ureter. *J. Urol.*, Nov., 1945, *54*, 434–437.

The number of reported cases of primary carcinoma of the ureter has been increasing but is still less than two hundred. The authors report a case in a forty-four year old soldier who had complained of urinary frequency for two months and gross painless hematuria for a few days before admission to the hospital. At that time cystoscopy was unsatisfactory although there was an impression of a mass at the right ureterovesical orifice. Intravenous urography showed a non-functioning right kidney. The patient was transferred to a hospital in the United States where a right-sided pyelogram showed a beginning hydronephrosis, a dilated ureter with a small filling defect in its distal portion.

The distal portion of the right ureter and the adjacent bladder was resected and a diagnosis of papillary carcinoma made. Postoperative pyelograms showed improvement in the previous right-sided hydronephrosis. Later at another hospital the right kidney and the remaining portion of the right ureter were removed but were found to be free from disease.—*R. M. Harvey.*

Muschat, M. Osteitis pubis following prostatectomy. *J. Urol.*, Nov., 1945, *54*, 447–458.

Osteitis pubis is an inflammatory process which occurs in a small number of patients following bladder operations, especially prostatectomies. It begins in the symphysis and spreads to involve the pubic rami as far as the ischii. Spasm of the obturator internus and levator ani muscles results from extension of the process. Pain is intense and disabling, lasting from three to twelve months.

The author reports 2 cases in detail. Both cases had prostatectomies. In each case the diagnosis was suspected clinically when pain in the groin began approximately three weeks postoperatively. In each case the diagnosis was confirmed by roentgen examination which showed early decalcification of the affected pubic bone. One case had operative removal of several small pieces of bone while the second case refused operation and had a slow prolonged recovery. In the patient who was operated on there was subsequent ankylosis of the symphysis.

The author then summarizes the 23 cases which have been reported in the literature. Beer appears to have been the first author to encounter a case. This case was seen in 1916 and reported in 1924. Muschat reviews the theories as to the etiology of the condition, none of which appears tenable. Clinically the pain usually appears ten days postoperatively and is over the symphysis, shifting to the crotch and inner thighs. Pain is severe. Recovery is slow. The diagnosis is made by roentgen ray, about the third week. The earliest changes are fraying of the periosteum of the symphysis with decalcification of the rami. Later bony ankylosis results. The differential diagnosis must include metastatic malignancy.

In treatment diathermy, baking, massage and roentgen therapy were of no avail. Body casts are not tolerated by the patient. Chemotherapy does not appear effective. The ultimate prognosis is good.—*R. M. Harvey.*

Young, H. H. The improved Young urological x-ray table. *J. Urol.*, Nov., 1945, *54*, 489–499.

The author constructed his first table for combined cystoscopic and roentgenologic procedures in 1915. Since that time he has made many modifications. This article describes the most recent of these modifications. Among the improvements in this latest model are facilities for roentgenography in the Trendelenburg position to show the upward range of the kidneys in nephroptosis, special Bucky diaphragm arranged for manual as well as magnetic release, self-centering cassette tray and provision for stereoscopic serial pyelograms with two exposures on a single film or serial pyelograms with three exposures on a single film. Other improvements are of interest to the urologist and not to the roentgenologist.—*R. M. Harvey.*

SKELETAL SYSTEM

Gill, Gerald G. A simple roentgenographic method for the measurement of bone length; modification of Millwee's method of slit scanography. *J. Bone & Joint Surg.*, Oct., 1944, *26*, 767–769.

This paper presents a simple modification of Millwee's slit scanography, which is highly ac-

curate and requires no complicated apparatus. Any smooth-rolling tube stand mounting a tube of 100 to 200 milliampere capacity may be quickly converted to this purpose.

In 1937, Millwee introduced slit scanography, a method designed to abolish distortion and overlapping of shadows in one plane. A continuous exposure was made by moving a narrow and transverse beam of radiation along the long axis of the part visualized. His equipment consisted of a mounted tube moved along a track by a worm gear and electric motor. A narrow transverse beam of rays was produced by an adjustable transverse slit. To safeguard further against scatter, a slotted lead apron was moved over the film and under the patient who was supported on a tunnel. This apron was connected to the tube stand by a side arm. In the roentgenogram obtained, provided an object was placed horizontal to and parallel with the run of the tube, there was no magnification of the image in this plane, regardless of the distance of the tube from the object or its height from the film. The transverse dimensions of the object, however, were distorted as in ordinary roentgenograms.

With the use of apparatus capable of 200 ma. output, Gill was able to overcome the difficulty of long exposure time used by Millwee. He also modified Millwee's apparatus by using a simple slotted lead plate instead of the tunnel and side-arm apron guide to produce the transverse beam of radiation. A transverse slit, 2 mm. in width, was cut in a lead piece which fitted the usual cone mounting. The tube was moved by a rope and pulley attached to a weight. When the weight was released, the tube was moved at a slow, constantly accelerating speed. The most satisfactory rate of motion was about 36 inches per ten seconds. If available, the planigraph may be easily converted into a scanographic apparatus. This method was used in a study of the growth of limbs following poliomyelitis and was found to be very satisfactory.—*R. S. Bromer.*

Schneider, W. F. Arachnodactyly; unusual complication following skull injury. *J. Pediat.*, Dec., 1945, *27*, 583–588.

Arachnodactyly was first reported by Marfan in 1896. The currently accepted opinion is that the disease is due to a congenital defect of the mesoblast. Clinical features of the disease include increased length of the bones of the hands, feet and extremities, pes planus, atrophy of muscles, deficiency of subcutaneous fat and increased joint mobility. A funnel-shaped chest is usually accompanied by precordial bulge, congenital heart defects and anomalies of the lungs. Multiple ocular defects include bilateral dislocation of the lenses, tremulous irises, myopia, shallow anterior chambers and retinitis pigmentosa. Mental deficiencies are a common finding in the disease entity.

The author reports a case in a thirteen year old female who was referred for psychiatric evaluation regarding school placement. Walking and speech formation had been delayed until the age of two. She was not accepted in school at the age of six because the teacher stated she was unable to see. Progressive visual failure occurred from this time until the age of thirteen. Roentgenograms of the hands showed "frailty of the osseous elements with tapering toward the distal ends of the metacarpals and some rarefaction of the distal ends of these bones." Grossly the patient presented typical "spider hands and feet." The author pleads for early recognition of the orthopedic defects and ocular deficiencies, and prompt institution of remedial measures followed by school placement and adjustment in line with the child's intellectual capacity.—*R. M. Harvey.*

Crowley, John J., and Olken, Harry G. An unusual traumatic cortical lesion of bone. *J. Bone & Joint Surg.*, Oct., 1945, *27*, 687–694.

A case of an unusual destructive lesion of bone is reported. The patient was first examined six months after trauma to the tibia. The lesion was limited to the cortex of the bone and showed no periosteal or medullary involvement. Histopathologically the cortical bone was replaced by fibrous tissue and giant cells. There was associated old and fresh hemorrhage, but there was no evidence of new bone formation.

The roentgenographic examination of the patient showed a localized, destructive lesion in the cortex of the right tibia, lower lateral aspect, about 2 or 3 inches above the ankle joint. The lesion involved the cortex only, and resembled somewhat a Brodie's abscess or a cortical cyst. No definite roentgenographic diagnosis was offered.

One striking feature of the lesion was the limitation of the destructive lesion to the cortex of the bone, which is a very unusual location for a benign tumor-like growth. Cortical lesions arising in the cortex are almost invariably in-

flammatory in nature or frankly malignant. A second striking feature was the outstanding absence of new bone formation. The lesion showed similarity of histopathologic patterns with the "non-osteogenic fibroma of bone" described by Jaffe and Lichtenstein but differed in that it was confined to the cortex and did not arise from the medulla of bone.

The authors conclude that the lesion does not fall within any definitely known category of bone pathology. It is best considered as a benign lesion which represents an unusual reparative response on the part of bone to injury.—*R. S. Bromer.*

KLEINBERG, SAMUEL. The solitary bone cyst; a report of a case of twenty years' duration. *J. Bone & Joint Surg.*, April, 1944, *26*, 337–344.

Kleinberg reports a case of a solitary bone cyst which had existed for somewhat more than twenty years without any mishap and without surgical intervention. The interesting features which prompted him to report the case are: (1) the natural progress of the lesion, uninfluenced by either trauma or an operation; (2) the benign character of this type of cyst, despite the long duration; (3) the continued, existence of the cyst, apparently disproving the belief that it may heal spontaneously; (4) the ease with which this type of cystic disease may be completely eradicated, and (5) the exceptionally good fortune which attended the patient, since, because of the location of the cyst, a pathological fracture would have led almost inevitably to a coxa vara deformity, and a functional disturbance in the hip and the limb.

The patient, a male, aged twenty-five, was seen first by the author in 1936 because of a cyst in the neck of the left femur which he knew had been in existence since he was about two years of age. Roentgenograms were available dating back to 1922. The cystic area extended downward across the intertrochanteric line into the femoral shaft. He was operated upon in June, 1942. Six months later a roentgenogram showed obliteration of the cystic cavity.

From his experience, the author feels that solitary bone cysts may exist for many years, and that they do not heal spontaneously. At varying periods of time, the process of bone erosion may become active, and weaken the bone so that there remains only a thin, bony shell subject to fracture from a comparatively mild trauma caused by a direct blow or muscle effort. From this observation, and from known operative results, he concludes that it is evident that the treatment of choice is an operation, the essentials of which are the thorough scarification of the bony cyst wall, and the filling of the cavity with bone grafts of cancellous and cortical bone. The operation should be performed as soon as the diagnosis has been established. He emphasizes that every part of the cavity should be thoroughly curetted and the cavity should then be completely filled with bone grafts.—*R. S. Bromer.*

HELFET, ARTHUR J. Acute manifestations of yaws of bone and joint. *J. Bone & Joint Surg.*, Oct., 1944, *26*, 672–681.

In this paper, the author stresses the more acute type of lesions produced by yaws in bone and joints, the type that requires urgent treatment. In his experience cases of yaws sent to the hospital for treatment presented more acute symptoms than those usually described as simulating the slow onset of syphilitic involvement of bone. The patients rarely gave a history of more than a few weeks' duration of symptoms. Whereas in syphilis a gummatous attack on a joint surface may not even be accompanied by muscle spasm or limitation of movement, in yaws a juxta-articular lesion may simulate arthritis of the joint itself, with pain, tenderness, swelling, muscle spasm, and limitation of movement. Where the shaft of a long bone is involved, a picture resembling a septic osteomyelitis may result, with intense pain, swelling, and pyrexia, although the fever is rarely high. The onset usually follows a trauma, often severe, and trauma cannot be discounted as a localizing, precipitating factor in what was a generalized latent disease. The onset may be accompanied by fever and widespread "rheumatic" pains, both of which last a few days. It is not until localizing symptoms and signs present themselves that yaws is suspected.

A roentgen picture, resembling that frequently observed in syphilis, may show increase in diameter of the bone, marked increase in density and single or multiple punched-out areas. More often, however, in the rapidly progressing type of yaws, the roentgenograms show subperiosteal necrosis of the cortex, with raising of the periosteum and deposition of periosteal new bone. Occasionally, this deposition of periosteal new bone is so marked that the roentgenographic appearance resembles that

of an osteogenic sarcoma or the "onion-layering" of a Ewing's tumor. The rapidity with which the roentgenographic appearance of the bone may change is demonstrated in the illustrations in the paper.

The author's method of treatment is operation with the use of arsenicals and he describes the response to treatment as dramatic. Roentgenographic evidence of consolidation of the lesion can be demonstrated usually within six weeks.—*R. S. Bromer.*

Hatcher, C. Howard. The development of sarcoma in bone subjected to roentgen or radium irradiation. *J. Bone & Joint Surg.*, April, 1945, *27*, 179–195.

In this paper, 3 cases are reported in which irradiation appears to have been responsible for the development of bone sarcoma. In each of the patients the tumor arose in normal bone which had been in the field of irradiation directed toward an earlier independent lesion. Twenty-four cases of bone sarcoma which followed roentgen or radium irradiation are reviewed. All except 6 of these occurred in association with chronic joint infection. To these Hatcher added his 3 cases of which 2 were chondrosarcoma and 1, fibrosarcoma. In all the cases except one, the amount of irradiation was large and was administered in fractional doses over a long period. The interval between irradiation and recognition of irradiation-produced sarcoma was long. The median time in the reported cases was six years. Chondrosarcoma occurred more frequently among the irradiation-produced sarcomas than in other bone tumors. The occurrence of the large proportion of cartilage-forming tumors was also noted in experimental animals as well as in human beings. Predisposition of the individual to neoplastic growth may be a factor in the development of irradiation sarcoma.—*R. S. Bromer.*

Howorth, M. Beckett. Echinococcosis of bone. *J. Bone & Joint Surg.*, July, 1945, *27*, 401–411.

Echinococcus disease is rare in this country but its increase may be expected, according to the author, because of conditions growing out of the War. Howorth regards its diagnosis, especially in bone, as not difficult, if its possibility is realized, and if proper laboratory tests and roentgenograms are made. Bone involvement occurs in about 1 per cent of cases. The larger series of cases reported show that the pelvis is involved in about 36 per cent, the sacrum in 11 per cent, the femur in 17 per cent, the tibia in 9 per cent and the humerus in 10 per cent. Pain is the most common symptom of bone involvement and is due to leakage or pathological fracture. Rupture or pathological fracture may be followed by infection, with pain, swelling, redness, and tenderness but a mass may be noticed before the onset of pain. The mass is usually rounded but somewhat irregular, firm or hard, but sometimes semifluctuant, not tender unless infected, and is attached deeply and firmly to the bone. Motion may be limited and painful if the mass is near a joint. Inflammatory signs are present if the cyst is infected and near the surface. A vertebral lesion may cause pressure upon the spinal cord or cauda equina, with spastic or flaccid paralysis, while the spinal fluid below the lesion may have a high protein content, and there may be a partial or complete block.

Scolices, hooklets, or fragments of laminated membrane may be found in the sputum, urine, or feces after rupture of a cyst. Howorth describes three immunological tests, dependent upon antibody reaction, which may be performed. He advises against aspiration or puncture of a cyst because of the danger of sensitizing the patient, of anaphylaxis if he is already sensitive, or of producing secondary cysts by implantation of the scolices which may escape into the tissues.

The roentgenogram is of great value in demonstrating the presence and location of the lesion, but it may not indicate its nature. The cyst is somewhat radiopaque because of its saline content and if in the lung fields it may be readily seen. The bone lesions in the roentgenogram are polycystic, with fairly sharp margins but without productive reaction or regional or subperiosteal decalcification unless infected. They must be distinguished from giant cell tumor, the cystic type of tuberculosis of the long bones, malignant tumor, osteomyelitis and osteitis fibrosa cystica. The surrounding bone may be thinned and even expanded or ruptured by the pressure of the lesion. Arterial erosion results in necrosis and small sequestra may be seen. Fracture through the involved area is not infrequent, and non-union often results.

The case reported in this paper is unusual because it is 1 of the 10 North American cases to be put on record, the first with femoral involvement and the only known instance in

which the cavity at time of operation was filled with bone chips after removal of the cyst.—*R. S. Bromer.*

Mayer, J. H. Chronic melioidosis; case showing multiple lesions of bones, joints and lungs. *J. Bone & Joint Surg.*, July, 1945, *27*, 479–485.

Melioidosis is an infective disease occurring in Burma, Ceylon, French Indo-China, the Dutch East Indies, Malaya and Siam. Several hundred cases have been recorded since the original description of the disease by Whitmore and Krishnaswami in 1912. In the vast majority, the disease has been acute, with symptoms simulating cholera or enteric fever, and has proved fatal from septicemia within a few days or weeks. At autopsy, the commonest findings recorded in such cases have been areas of consolidation and small abscesses in the lungs, and abscesses or areas of caseation in the spleen, liver, and kidneys. In some cases there was recovery from the primary attack followed by a fatal septicemia in which pulmonary lesions resembling tuberculosis were found at autopsy.

The chronic form of the disease is much less common. The author was able to find 5 cases in the literature, only 2 of them occurring in Europeans. He regards, however, early recognition of the disease as of vital importance because of the employment of large Allied forces in Far Eastern areas where the infection is endemic. Melioidosis is recognized as a disease of rodents and man; it is generally assumed that infection in man is acquired from infected rodents, possibly by contaminated food or water supplies. The causative organism is now known as *Pfeifferella whitmori* or *Malleomyces pseudomallei*.

He reviews the 5 cases previously reported and adds a further report on one previously presented by him. He regards his case as important because of its singular resemblance to tuberculosis. It had been incorrectly diagnosed for nearly three years despite repeated bacteriological investigations, and it seems highly probable that similar cases have remained, and may remain unrecognized.

The roentgenograms of his patient showed collapse of the body of the eighth thoracic vertebra with a large paravertebral abscess and no narrowing of the intervertebral discs, slight sclerosis of the adjacent vertebral bodies at the lumbosacral joint with narrowing of the disc space, extensive infiltration at the base of the right lung, bilateral hilar enlargement, and bilateral pleural thickening. Later roentgenograms showed extensive destruction of the right femoral head and of the acetabular roof with adduction and dislocation, destructive changes in the right sacroiliac joint, increased irregularity of the surfaces of the lumbosacral junction, increased wedging of the eighth thoracic vertebra, slight clearing of the right lung and slight mottling in the left lung.

After approximately two years of treatment the patient was much improved, which may be attributed to the combined use of autogenous vaccine and sulfadiazine therapy. The author believes that abscesses should be drained early and adequately.—*R. S. Bromer.*

Kenney, William E. Polymorphous-cell sarcoma, the malignant phase of giant-follicle lymphoma, with generalized skeletal involvement and multiple pathological fractures. *J. Bone & Joint Surg.*, Oct., 1945, *27*, 668–673.

In 1925, Brill, Baehr, and Rosenthal described a disease entity which was characterized by splenomegaly and generalized lymphadenopathy. The pathological change was one of qualitative and quantative hyperplasia of the follicles of lymphoid tissue to such an extent that it was called giant lymph follicle hyperplasia. Further studies revealed that the tumor could undergo a malignant transformation. Symmers has discussed the relation of such a malignant phase to Hodgkin's disease and lymphatic leukemia. The association of the condition with various skin lesions was presented by Combes and Bluefrab. In only one case was a single pathological fracture encountered. Little mention is made in the literature of the ability of polymorphous cell sarcoma to invade bone. Kenney's case is of interest from several standpoints. There were at least seven pathological fractures, and the entire skeleton was involved. The diagnosis was supported by biopsy as well as by autopsy, which revealed changes in the tumor from site to site, so that in different microscopic sections it resembled Hodgkin's disease, reticulum cell sarcoma, polymorphous cell sarcoma, and giant follicle hyperplasia. The age of his patient was greater than in other cases reported. The presenting complaint was a pathological fracture, rather than enlarged lymph nodes. Numerous labora-

tory procedures were remarkable for their normal results.

The article contains illustrations of roentgenograms of the involved bones and of pathological sections.—*R. S. Bromer.*

Rule, Colter, and Grollman, Arthur. Osteo-nephropathy: a clinical consideration of "renal rickets." *Ann. Int. Med.*, Jan., 1944, *20*, 63–74.

The authors prefer to use the term osteo-nephropathy since it indicates the nature of the presenting symptoms without implication regarding pathogenesis, as in the term "renal rickets."

The following etiological classification of osteo-nephropathy is given.

A. Due to primary urinary tract disturbances.

1. Chronic glomerulonephritis, pyelonephritis, nephrosis.

2. Congenital malformations: Polycystic kidneys, renal hypogenesis.

3. Urinary tract obstruction with secondary renal lesions: Urethral valves: prostatic enlargement; calculi; strictures of urethra, bladder neck or ureter; hydro-ureter.

4. Primary tubular functional changes which may or may not show anatomical changes.

a. Hypochloremic-glycosuric type (deToni-Fanconi syndrome)

b. Hyperchloremic type without glycosuria

B. Due to primary extra-renal disturbances

1. Endocrine disease

Hyperparathyroidism (osteitis fibrosa cystica)

2. Metabolic disturbance

Cystine storage disease

The determination of the nature of the disorder rests ultimately on the accessory clinical studies, especially upon the chemical studies of the blood and urine. The roentgenogram in some cases may indicate the fundamental disorder by showing bone cysts characteristic of primary hyperparathyroidism, calcification in the kidney, or other changes in the genito-urinary tract.—*James J. McCort.*

Blattner, R. J., and Sung, C. Cystic tuberculosis of the bone in a case of miliary tuberculosis. *J. Pediat.*, Dec., 1945, *27*, 579–582.

Cystic tuberculosis of the bones is especially rare in children. Schwentker, who reported the first case in this country, divided tuberculosis of the long bones in children into two groups: those in the diaphysis, and those in the metaphyso-epiphyseal region. Cystic lesions occur in the latter area but when the lesion is in the diaphysis it is modified by the periosteal reaction. The presence of multiple cystic lesions in long bones requires the consideration of osteitis tuberculosa multiplex cystoides, which is now felt to be a form of sarcoid, and multiple cystic tuberculosis in the differential diagnosis.

The authors report a case of a two year old white male who was admitted to the hospital with a complaint of otorrhea of six months' duration, and cough, vomiting and listlessness which had been present for two weeks. The child had been drinking unpasteurized milk since the age of six months. Some stiffness of the neck had been noticed prior to admission. Clinical findings and roentgen examination of the skull revealed increased intracranial pressure. A chest film showed increased hilar density on the right and a fine parenchymatous mottling throughout both lung fields. Examination of the right tibia disclosed a rarefied area in the lateral half of the proximal epiphysis enclosed by a zone of compact bone. A diagnosis of xanthoma was made on the basis of these findings. Aspiration of this lesion was done and 4 cc. of thick white pus obtained. A guinea pig inoculation of this pus was positive for tuberculosis. Tuberculosis of the liver, lungs, spleen, leptomeninges and the lesion in the right tibia was confirmed at autopsy.—*R. M. Harvey.*